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Further Studies in Retroactive Inhibition

BY

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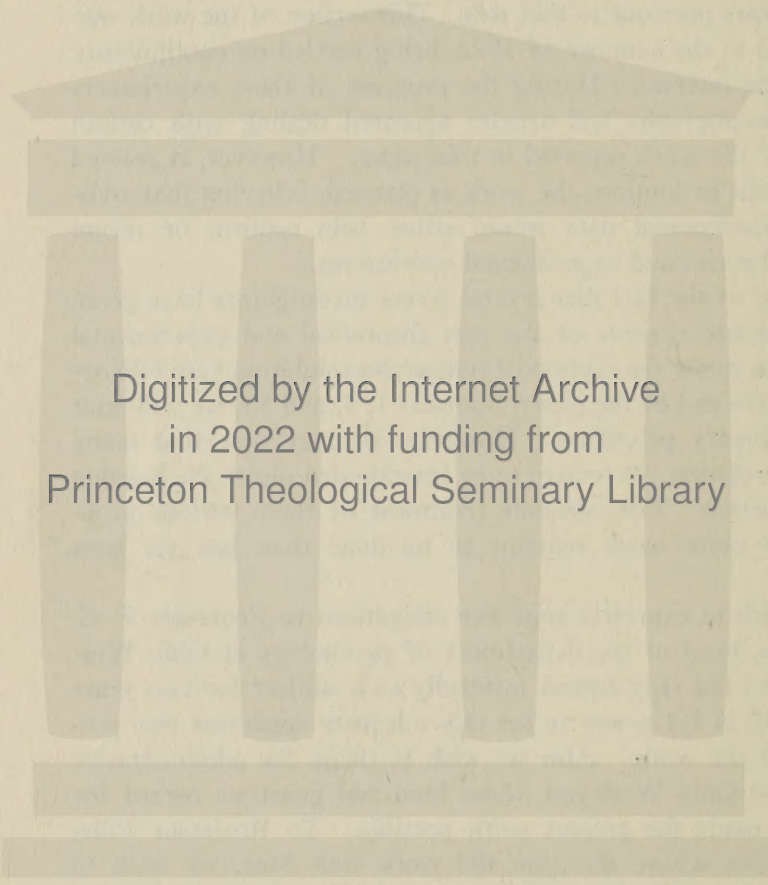
PREFATORY NOTE

The experimental investigations reported in this paper were begun in the fall of 1920, although interest in the problem and some preliminary probing (largely by group methods) goes back several years previous to that date. This section of the work was completed in the summer of 1922, being carried on continuously during the interval. During the progress of these experiments several monographs and articles appeared dealing with certain phases of the work reported in this paper. However, it seemed worth while to continue the work as planned, believing that additional experimental data would either help confirm or refute present theories and experimental conclusions.

In view of the fact that several recent investigators have given very complete reviews of the past theoretical and experimental work done under the caption of retroactive inhibition (see bibliography at the end of the paper, numbers 1, 4, and 5), we will omit this customary procedure. However, we may note that many specific problems yet remain to be investigated under the heading of retroaction. For adequate treatment of these various problems far more work remains to be done than has yet been reported.

We wish to expressly state our obligations to Professor F. C. Dockeray, head of the department of psychology at Ohio Wesleyan, who not only served faithfully as a subject for two years but did all in his power to see that adequate apparatus was provided for the work. Also we wish to thank the administrative officers of Ohio Wesleyan whose kind and generous regard for research made the present work possible. To Professor Pillsbury, under whose direction the work was done, we wish to express our appreciation for his various suggestions and encouragement in the work. Last of all, we must express our appreciation to Mrs. E. B. Skaggs, who not only served throughout as a trained subject but also acted as experimenter when the writer worked as subject.



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PART I. EXPERIMENTAL SECTION

INTRODUCTORY STATEMENTS, DEFINITIONS AND ASSUMPTIONS

Meaning of the term "retroactive inhibition." In this paper the terms retroactive inhibition, retroactive interference or blocking, and retroaction will be used interchangeably. If any given mental (neural) activity B, following a previous learning process A, works detrimentally upon the retention and recall of learning A, we denote the fact by saying that there has been retroactive inhibition. We are using the term, not as any theory, but merely as a handy grouping for a number of phenomena. In psychiatrical work cases are reported under the heading of retrograde amnesia. Here some physical shock or emotional disturbance seems to blot out the possibility of recall of events just preceding the shock. While these cases may involve very different principles of explanation from those facts reported in this paper, we are inclined to classify them under the heading of retroactive inhibition. On the more normal side, if one forms a given series of associations and then turns to other vigorous mental work (with or without emotional aspects), and finds that the original learning is recalled in an unsatisfactory way or not at all, then we indicate this fact as due to retroactive interference.

Subjects used in the experiments. We may classify our subjects into three groups. One group may be called the "trained group." F. C. Dockeray, Mrs. E. B. Skaggs, and the writer constitute this group. All were trained in the art of giving keen and thorough introspections and were able to adjust themselves to the conditions of the experiment.

The second group may be called the "semi-trained group." They were students who were taking advanced courses in psychology following a year of general psychology, involving laboratory work. One of these was a graduate student (R. M. B.). All were faithful in trying to live up to the conditions of the

experiments. Their introspections were usually inferior to those of the trained group.

The third group consists in untrained subjects taken from the writer's classes. The number of records from each of these subjects was usually small, and hence we must rely upon the central tendency of each group for indication of the actual facts. In all cases these subjects were used as checks, although their results were often quite convincing.

The work and rest intervals. As we must in some way compare results under conditions where mental activity follows the original learning with those results where a period of rest followed the learning, it is very necessary to control these two mental conditions. In one case we want an extreme of mental struggle and attention. In the other case we want the subject to be just as passive mentally as possible—to relapse into a condition of lazy, passive perception. We have used the term Work Interval to denote a period of vigorous mental activity. The term Rest Interval denotes a period of relative mental quietude and relaxation. We have made no attempt to secure a graded series of mental conditions ranging from one of these extremes to the other. Our best rest period never represents complete passivity (this presumably would be death), but merely a condition of relatively little thought and effort.

We believe that, on the whole, our subjects have been fairly successful in taking these two mental attitudes, one of work and one of rest. Each subject was told as clearly as possible our conception of a good rest and a good work period. In the rest interval the subject was urged to relax and assume a lazy, indifferent attitude. He was told not to worry about the score he made and to get away from the learning material as far as possible. If at any time some part of the original learning came to mind he was to take a discouraging attitude toward it and get it out of his mind as best he could. In the case of the work interval he was told to work as if his " life depended upon it."

Introspections. The introspections are absolutely essential in the following experimental work. Without these introspections the experimenter is unable to classify the rest and work interval.

Only a complete history of what went on in the subject's mind can permit the experimenter to say that "this is a good rest period free from any return to consciousness of the original learning material," or "this is a fair rest period in which fragments of the original learning came to mind," etc. It is upon the introspections of the three trained subjects that we have relied for the most part. Our group two (semi-trained subjects), however, contributed valuable introspective reports.

While the introspective reports have not been given in this paper they have been taken carefully and in detail. Several tables and important conclusions have been based entirely upon the introspective reports.

The use of short intervals. Our experiments everywhere employ very short rest and work intervals. Longer intervals were used at first (*e.g.*, fifteen minutes) but very quickly abandoned. Long intervals bored our subjects and made it very hard to control the rest interval. Long intervals put a premium upon all sorts of mental activity. Again, it was almost impossible to get the detailed introspections which we desired after a long interval.

Program of investigation. All experiments were performed individually. The writer was experimenter in all cases excepting when he himself served as subject. In the latter case I. D. S. served as experimenter. The so-called "reconstruction test" was used as test material in Part II (following). In Part III a little work is reported in which unconnected sense words were used as learning material. Nonsense syllables constituted the learning material in Part III of this report.

We have attempted to gain some further data upon several major problems. First, Is there any definite evidence of retroactive inhibition? Here we have compared results after work and rest intervals. Second, Does the temporal position of the interpolated work affect the degree of retroaction? Here we have varied the temporal position of the work interval while keeping other conditions as constant as possible. Third, Is there greater retroaction when the work material is similar or dissimilar to that of the original learning? Is there any relation between

the degree of this similarity and the amount of retroactive inhibition? Fourth, Is retroaction greater in the morning or evening—when the subject is relatively fresh or when fatigued? Fifth, What is the effect of practice in a given learning material upon its susceptibility to retroaction?

PART II. EXPERIMENTAL SECTION

RECONSTRUCTION TEST AS LEARNING MATERIAL

Experiment Series A. Comparison of Rest versus Work Intervals

In this series of experiments our problem may be stated as follows: Is there any positive evidence of retroaction under the conditions of our experiment? These conditions are: using the reconstruction test for original learning; short exposure (learning) of material; short interval of work or rest; addition as the interpolated work; and using the central tendency as index for comparative purposes.

The reconstruction test was used extensively because (1) other workers had used it to some extent (DeCamp and Robinson) and (2) because we found that it lent itself admirably to the experimental needs.

Apparatus and Method: A chess board 12 x 12 inches was framed and covered with glass. Five chess men were used, viz., the queen, castle, bishop, knight, and pawn. A large white cardboard 20 x 24 inches was arranged to slide up and down on a horizontal rod above the table, being used to screen the chess board and experimenter from the subject when needed. A stop watch was used in the timing.

The subject sat on one side of the table, the experimenter on the other. The screen being down, E. arranged the chess men on various spots, under a prearranged schedule. At a warning signal of "ready" E. lifted up the screen and exposed the chess formation. S. was then given fifteen seconds in which to study the arrangement. The card was then dropped. The experiment now took one of two forms, as the case might be. Either (1) S. relaxed and was at rest for a given interval or (2) S. worked attentively adding columns of two place numbers. Three differing intervals have been used, namely, a half minute, a minute, and

a two-minute interval. At the end of the given interval, work or rest, the screen was raised and S. tried to reconstruct the formation. The time was recorded from the time S. began to reconstruct until he signified that he had finished. S. added aloud and a record of his performance was kept. However, the amount of work thus done in the work interval is nowhere given in this paper, as it was found to be a relatively constant factor.

The errors are calculated in the same manner as that noted in DeCamp's work. Thus, if the queen was located by E. as four rows up and six columns over to the right our original record read simply, 4–6. If S. replaces the queen as 5–7, then the total errors are one for the row displacement and one for the column displacement, or a total of two errors.

On any given experiment day six individual experiments were done, three of work and three of rest. The intervals were alternated for the following subjects: F.C.D., I.D.S., E.B.S., M.S., F.Bl., and Deus. Consequently each subject in this group knew what experiment was coming next. In the case of subjects R.M.B., R.S., W.A.D., and Sh., the experiments were presented in irregular order, and hence these subjects did not know what to expect next. An interval of from two to three minutes elapsed between each individual experiment in the day's series.

The following tables (I to V, inclusive) give the Means and M.V. for the ten trained subjects and for ten untrained subjects. (It is to be mentioned that only subjects I.D.S. and F.C.D., and E.B.S. knew definitely the nature of the problem.) For the most part the averages for the trained subjects are based upon twenty experiments for each work and rest interval. As we desired some data of a comparative nature between morning and evening conditions, three subjects have thus data for both these times.

SUMMARY TABLE I

SHOWING AVERAGES AND MEAN VARIATIONS FOR 10 TRAINED SUBJECTS. RECONSTRUCTION TEST. COMPARING WORK VS. REST INTERVALS. MORNING RECORDS. ONLY ERRORS CONSIDERED

Subject	0.5′ Interval				1.0′ Interval				2.0′ Interval			
	Work		Rest		Work		Rest		Work		Rest	
	Er.	M.V.	Er.	M.V.	Er.	M.V.	Er.	M.V.	Er.	M.V.	Er.	M.V.
E.B.S.	7.9	4.28	5.35	3.72	9.25	6.55	7.00	4.6	15.50	5.9	8.70	6.47
F.C.D.	8.3	5.00	4.30	3.70	10.10	8.30	4.50	4.0	13.50	7.3	5.40	3.20
I.D.S.	8.7	6.50	4.20	3.60	11.20	6.30	5.70	5.2	12.10	7.3	6.30	5.10
M.S.	9.3	4.90	3.00	2.90	10.20	5.40	6.50	3.6	9.40	5.8	8.80	5.90
F.Bl.	.....				8.20	4.80	1.30	1.7	5.10	4.3	2.50	3.00
Deus.	.....				3.80	4.16	6.50	5.8	7.60	5.7	9.80	6.00
R.M.B.	.....				5.67	5.12	7.08	5.0	6.33	3.8	5.75	4.18
W.A.D.	.....				8.12	4.68	6.12	6.2	2.78	2.6	3.89	3.6
R.S.	.....				12.17	5.83	7.17	5.1	12.50	4.6	10.83	5.68
Sh.	.....				11.67	6.59	7.67	5.1	.....			
Total	34.2		16.85		90.38		59.54		84.81		61.97	
Mean	8.55		4.21		9.04		5.95		9.42		6.88	
M.V.	.45		.61		2.07		1.27		3.53		2.24	

EXPLANATORY NOTES.—Each average given for E.B.S., F.C.D., I.D.S., M.S., and F.Bl. is based upon 20 experiments. Averages for Deus. based upon 15 experiments; for R.M.B., 12 experiments; for W.A.D., 8 experiments; for R.S., 12 experiments; and for Sh., 9 experiments. Experiments done between 7 and 9 A.M. for E.B.S., I.D.S., and F.C.D.; between 10 and 12 for other subjects. Time kept same for each subject.

TABLE II

SHOWING AVERAGES AND MEAN VARIATIONS FOR 10 TRAINED SUBJECTS. RECONSTRUCTION TEST. COMPARING WORK VS. REST INTERVALS. MORNING RECORDS. ONLY TIMES CONSIDERED

	0.5′ Interval				1.0′ Interval				2.0′ Interval			
	Work		Rest		Work		Rest		Work		Rest	
	T.	M.V.	T.	M.V.	T.	M.V.	T.	M.V.	T.	M.V.	T.	M.V.
E.B.S.	66.65	25.45	59.20	19.10	74.00	26.70	61.95	32.5	70.00	21.60	68.50	28.40
F.C.D.	43.70	18.50	35.20	18.70	56.60	24.20	40.30	16.8	80.60	32.30	39.80	19.60
I.D.S.	71.30	31.90	57.40	22.00	76.70	30.00	54.30	19.1	96.60	40.60	64.00	27.30
M.S.	81.00	36.00	72.00	38.00	117.00	43.00	92.00	32.0	113.00	36.00	81.00	18.00
F.Bl.	.....				36.70	15.30	26.10	8.0	33.70	19.50	22.50	4.90
Deus.	.....				61.90	34.10	38.30	39.2	99.30	54.50	79.50	41.00
R.M.B.	.....				44.60	19.40	58.90	29.4	50.90	17.60	49.50	14.20
W.A.D.	.....				31.80	6.00	27.10	3.6	23.40	7.60	25.40	7.80
R.S.	.....				95.60	33.10	84.25	19.41	98.60	31.30	83.30	21.60
Sh.	.....				65.20	27.30	42.30	16.9	.....			
Total	262.65		223.8		660.1		555.5		666.1		513.5	
Mean	65.66		55.95		66.01		55.55		74.01		57.05	
M.V.	10.98		8.38		19.85		17.53		26.12		20.20	

EXPLANATORY NOTES.—See notes for Table I.

TABLE III

SHOWING AVERAGES AND MEAN VARIATIONS FOR 10 TRAINED SUBJECTS. RECONSTRUCTION TEST. COMPARING WORK VS. REST INTERVALS. EVENING RECORDS. ONLY ERRORS CONSIDERED

	0.5′ Interval				1.0′ Interval				2.0′ Interval			
	Work		Rest		Work		Rest		Work		Rest	
	Er.	M.V.	Er.	M.V.	Er.	M.V.	Er.	M.V.	Er.	M.V.	Er.	M.V.
E.B.S.	5.25	3.80	5.40	4.70	7.30	5.10	4.75	4.60	12.45	6.80	7.20	4.60
F.C.D.	7.95	5.60	3.70	3.60	6.50	6.50	2.90	2.70	10.60	7.00	3.60	4.10
I.D.S.	7.60	5.20	1.95	1.80	7.80	6.30	4.30	3.99	9.70	6.40	3.20	3.70

EXPLANATORY NOTES.—All averages based upon 20 experiments for each work and rest interval or a total of 120 experiments for the whole table. All experiment series done between 7 and 9 P.M.

TABLE IV

SHOWING AVERAGES AND MEAN VARIATIONS FOR 10 TRAINED SUBJECTS. RECONSTRUCTION TEST. COMPARING WORK VS. REST INTERVALS. EVENING RECORDS. ONLY TIMES CONSIDERED

	0.5′ Interval				1.0′ Interval				2.0′ Interval			
	Work		Rest		Work		Rest		Work		Rest	
	T.	M.V.	T.	M.V.	T.	M.V.	T.	M.V.	T.	M.V.	T.	M.V.
E.B.S.	59.95	18.80	60.55	21.80	56.65	24.20	64.20	33.70	74.10	24.00	62.50	19.80
F.C.D.	50.00	16.00	34.00	10.00	48.20	20.80	36.00	15.00	65.00	29.00	52.00	33.00
I.D.S.	72.20	41.20	45.00	22.00	68.80	24.30	58.70	24.50	87.10	34.00	46.40	22.70

EXPLANATORY NOTES.—Same as for Table III.

TABLE V

SHOWING COMPARATIVE RESULTS AFTER WORK AND REST PERIODS FOR 10 UNTRAINED SUBJECTS. AVERAGES BASED ON 6 RECORDS FOR EACH METHOD PER SUBJECT. 1′ INTERVAL USED

Sex	Work Interval Er.	Work Interval Time (″)	Rest Interval Er.	Rest Interval Time (″)
Female	8.5	48.8	2.1	24
Female	11.2	41.2	10.0	36.2
Male	10.0	143.8	6.8	125
Male	4.5	88.7	5.0	87
Female	9.2	103.3	3.8	93.3
Male	12.0	57.3	8.5	51.2
Female	6.7	44.0	6.5	67.0
Female	9.3	70.1	2.7	37.1
Female	10.8	27.0	3.8	24.7
Male	8.5	38.8	9.3	33.3
Total	90.7	663.0	58.5	578.8
M.	9.07	66.3	5.85	57.9
M.V.	1.61	28.7	2.37	28.2

A study of the foregoing data indicate the following: (1) As regards errors made, the case is quite clear for all intervals used—in the case of trained subjects. The performance after the rest is much better than after the work interval.

(A) For the half-minute interval the mean error is more than twice as large after the work than after the rest interval (8.55 as compared with 4.21).

(B) For the minute interval we also find the average error clearly larger for the work interval (9.04 as compared with 5.95).

(C) For the two-minute interval we likewise find more errors after the work.

(2) Considering the above data with regard to individual performance rather than group average, we find:

(A) For the half-minute interval all subjects do markedly better after the rest interval.

(B) For the minute interval, where we have ten cases, eight subjects do better after the rest interval. Deus., one of the exceptions, persistently reported an inability to take a restful, passive attitude, and we suspect that her so-called rest period was as strenuous as her work period. R.M.B., the other exception, reported a similar con-

dition, with the added fact that the adding was very easy for him.

(C) For the two-minute interval (nine subjects) we again find two apparent exceptions, namely, Deus. and W.A.D. We believe that we can easily explain the record of Deus. (as above stated). W.A.D. has a mean based only on eight records and moreover could hardly be called a trained subject.

(3) As regards reconstruction times, our summary table II shows that the mean time is consistently longer for the work than for the rest periods.

(4) The evening records for subjects F.C.D., I.D.S., and F.C.D. (Tables III and IV) show the same thing—there are markedly more errors after the work than after the rest interval.

(5) Table V gives the results for ten untrained subjects. Here only the one-minute interval was used and the records are based upon only six experiments for each work and rest interval. Inspecting the group averages, we find (1) more errors are made after the work than after the rest intervals (9.07 as compared to 5.85) and (2) the reconstruction time is longer after the work. Looking at the data from the standpoint of individual performance, we find that eight out of the ten subjects do better after the rest interval.

Supplementary Control Series

(A)

It may be objected that the reason our subjects did more poorly after the work series was due to the fact that they were fatigued. Or, again, it may be objected that directly after the work the subject was so far removed from a "reconstruction attitude" that he could not get back into this attitude easily and so gave up too quickly. Our work intervals were so short (two minutes being the longest) that the fatigue objection seems out of the question. As six experiments were done in succession, with a small interval between each, there would have to be a most

remarkable oscillation between fatigue and recovery for these short intervals—something quite foreign to what we know of nerve and muscle fatigue. Müller and Pilzecker and Heine have also demonstrated that the above objections are largely insignificant. As regards the attitude objection, we have often found that the subject was " farther away " from the experiment at the end of the rest than after work.

However, a control series of experiments was done, largely to meet the above objections. The reconstruction test was used as before. The exposure time was fifteen seconds. The work consisted in adding two columns of figures simultaneously. The total time elapsing between learning and reconstruction was three minutes. In one case the subject rested for three minutes. In the other case the subject worked immediately for one minute and then rested the last two minutes. This experiment should largely do away with the above objections. Four subjects did the experiments, the order of presentation being irregular in all cases. The averages are given in Table VI.

TABLE VI

Subject	Work Interval Er.	Work Interval Time	Rest Interval Er.	Rest Interval Time	No. Records Based Upon
R.S.	12.3	57.8	4.6	47.6	10
F.C.D.	12.0	37.0	3.45	34.0	9
E.B.S.	5.46	35.8	6.15	48.5	13
I.D.S.	5.80	53.9	3.6	47.2	10

As in the foregoing experiments, we find here a clear retroactive effect for three subjects. E.B.S. alone shows no retroaction; in fact, the reverse is true. We can offer no explanation for this change excepting that through constant practice the subject learned the formations so well that no retroaction could operate.

(B)

There may be a further objection to our view that the work activity in some way actually is detrimental to the previous learning. The introspections of our subjects indicated that many rest intervals were characterized by at least some consciousness of the original learning. This consciousness would vary from a mere

vague and fleeting thought of the learning to a vivid picture repeated a number of times. It may be claimed that the advantage of the rest interval lay in this very fact, namely, that during the rest the subject repeated the learning whereas during the work he could not. The point is a very crucial one. We have carefully gone through the records of subjects F.C.D., I.D.S., and E.B.S., selecting, upon the basis of their introspections, those rest records which were free from any consciousness of the original

TABLE VII

COMPARING AVERAGES OF SELECTED REST INTERVALS WITH WORK INTERVALS AND WITH TOTAL UNSELECTED REST INTERVALS. RECONSTRUCTION TEST. THREE TRAINED SUBJECTS. MORNING AND EVENING RECORDS. ONLY ERRORS CONSIDERED.

	0.5′ Interval		1.0′ Interval		2.0′ Interval	
Subject	Rest	Work	Rest	Work	Rest	Work
Morning Records						
I.D.S.	3.88	8.70	3.00	11.20	8.70	12.1
	N, 17		N, 8		N, 3	
	(4.2)		(3.0)		(6.3)	
E.B.S.	6.30	7.90	7.85	9.25	8.57	15.5
	N, 17		N, 14		N, 14	
	(5.35)		(7.0)		(8.70)	
F.C.D.	4.20	8.30	2.00	8.30	3.20	13.5
	N, 5		N, 3		N, 5	
	(4.3)		(4.5)		(5.4)	
Evening Hour						
I.D.S.	1.60	7.60	4.83	7.80	3.86	9.70
	N, 10		N, 6		N, 7	
	(1.95)		(4.30)		(3.20)	
E.B.S.	3.20	5.35	4.83	7.30	5.44	12.45
	N, 10		N, 12		N, 9	
	(5.40)		(4.75)		(7.20)	
F.C.D.	3.20	7.95	3.50	6.50	3.00	10.60
	N, 4		N, 8		N, 3	
	(3.7)		(2.9)		(3.6)	

EXPLANATORY NOTES.—N represents the number of records upon which the average of the selected rest interval is based. The average given under Work is understood as based upon 20 records. The number in parentheses gives the average for the *total* unselected rest intervals as given in the preceding tables I and III.

learning, with the exception of a short after-image which was always present. These three subjects' records have been chosen because they furnish the most reliable and detailed introspections. Table VII gives the results in summary form. The data show that not only are these selected records confirmatory of our above stated view of retroaction, but the averages for the selected rest intervals are BETTER than the average for the whole series from

which they are taken. We are not surprised at this, for we recall that the subject often said that the consciousness of the original material was vague, indefinite, and merely signified that he was not sure of the learning. While some of the return thoughts of the original learning may have helped the subject in the rest experiments, we believe that there is evidence that the rest period gains its advantage over and above this.

We believe that our data amply justify us in saying that attentive work, following the original learning of the reconstruction test, works in some positive way a clearly detrimental influence on the retention and recall of this original learning.

Experiment Series B. Comparison of Retroactive Effects under Conditions of Fatigue

Tolman (5) found evidence that retroaction is greater for evening than for morning conditions, suggesting that retroaction operates more clearly under conditions of fatigue. Following are two studies which bear upon this problem:

(1) *Comparison of average error and retroaction in the initial and final experiments of a day's sitting.*

It will be recalled that at a given sitting six experiments were performed. We may assume that the subject was at least slightly fatigued at the end of the session. In the following tables (VIII and IX) we present the averages for the initial and final experiments for four trained subjects. Thus, *e.g.*, our day's experiments would be 1, 2, 3, 4, 5, 6—the odd numbers representing work, the even numbers rest, intervals. We thus compare 1 and 5 and

TABLE VIII

Comparing Average Errors and Retroaction in First and Last Experiments in Series

Subject	Position in Series	0.5′ Interval W	R	W–R	1.0′ Interval W	R	W–R	2.0′ Interval W	R	W–R
					Evening Hour					
E.B.S.	First	5.4	8.0	(–2.6)	8.0	5.0	(3.0)	12.0	8.6	(3.4)
	Last	5.2	2.0	(3.2)	6.2	6.5	(–.3)	8.6	5.2	(3.4)
I.D.S.	First	6.5	2.0	(4.5)	3.5	2.4	(1.1)	3.5	2.4	(1.1)
	Last	10.4	2.6	(7.8)	12.1	4.1	(8.1)	13.6	5.2	(8.4)
F.C.D.	First	8.0	6.0	(2.0)	3.0	2.7	(0.3)	5.3	1.1	(4.2)
	Last	10.5	8.5	(2.0)	13.2	4.9	(8.3)	17.5	7.1	(10.4)

2 and 6 in order to answer whether more errors are made in the final experiments of a day's series. To find out whether retroaction is greater or less in the first or last part of the day's series, we have taken the difference between 1 and 2 and compared it

TABLE IX

Comparing Average Errors and Retroaction in First and Last Experiments in Series

Subject	Position in Series	0.5′ Interval W	R	W–R	1.0′ Interval W	R	W–R	2.0′ Interval W	R	W–R
					Morning Hour					
E.B.S.	First	7.4	4.6	(2.8)	11.9	7.0	(4.9)	11.9	11.2	(–.3)
	Last	8.6	7.4	(1.2)	8.5	6.4	(2.1)	11.4	7.4	(4.0)
I.D.S.	First	6.6	1.4	(5.2)	8.0	3.7	(4.3)	10.2	3.7	(6.5)
	Last	13.0	6.5	(6.5)	13.3	7.7	(4.0)	13.4	6.4	(7.0)
F.C.D.	First	5.4	2.1	(3.3)	5.3	2.5	(2.8)	8.7	3.1	(5.6)
	Last	9.8	8.1	(1.7)	10.1	6.0	(4.1)	17.1	6.7	(10.4)
M.S.	First	8.0	5.6	(2.4)	8.4	5.9	(2.5)	4.4	4.5	(–.1)
	Last	9.3	1.4	(7.9)	13.0	6.4	(6.6)	11.5	12.5	(1.0)

with the difference between 5 and 6. The figures in parentheses give the retroaction; the other figures give the average error made.

An examination of the preceding tables shows that the average error for both work and rest intervals is larger for the final experiments in a day's sitting as compared with the average error for the initial experiments. Thus we find that out of twenty-one possible comparisons in our tables fifteen give a larger error for the final series, in case of the work intervals. Likewise, in case of the rest intervals, seventeen out of the possible twenty-one comparisons indicate greater error for the final experiments. This may be due to fatigue or some intra-system inhibitory conditions which operate more as the experiments proceed. Both of these factors may work together.

As regards the relative amount of retroaction, we find, comparing the figures in parentheses, that the greater retroaction occurs in the final experiments of the day's series. Out of the twenty-one possible comparisons, fourteen give greater retroaction for the final experiments. In two comparisons there is apparently no difference.

The facts seem fairly clear, indicating that in a learning process extending over about an hour's duration there is more retroaction

for the material learned near the end than for that learned near the beginning of the process. Doubtless we are dealing with a condition of accumulated fatigue plus a slackening of interest or incentives to do one's best in the final experiments of the day's sitting. Also there must be added a possible accumulative system of interferences due to the previous learning. Our subjects constantly reported that they could think of previous constructions and that it troubled them. However, until we disentangle the respective influences of the two above mentioned general factors, we do not feel safe in declaring that our findings support Tolman's conclusions. The presumption would seem to be that retroaction finds a fertile soil upon which to work in the case of fatigue condition or where the learning itself is poor.

(2) *Comparison of retroaction under morning and evening conditions.*

The second part of our present contribution to the question of the relation between retroaction and fatigue is based upon a comparison of retroaction under morning and evening conditions. Subjects F.C.D., I.D.S., and E.B.S. did evening experiments (7 to 9 P.M.) in addition to morning experiments (7 to 9 A.M.). The morning and evening experiments were carried out in alternating fashion, thus ruling out practice effects. No subject did morning and evening experiments on the same day. Our assumption is that the subject is more fatigued in the evening than in the morning—that morning represents a condition of relative freedom from fatigue.

In order to decide whether there is greater retroaction present in the evening experiments certain conditions must be fulfilled: (1) The average error difference between the work and rest series in the morning must be LESS than the average error difference between the work and rest series in the evening; (2) the learning in the evening for the rest series and work series must be as good as that in the morning, otherwise the difference between morning and evening results may be due to difference in degree of learning in the morning and evening.

Using a series of conventional symbols we may put the matter

thus: Let Er.W stand for the average error in the morning work series; let Er.R represent the average error in the morning rest series; let Er.w stand for the average error in the evening work series; and finally let Er.r signify the average error for the evening rest series. Then if there is greater retroaction in the evening, we have

$$\text{Er.W—Er.R} < \text{Er.w—Er.r},$$
$$\text{Granting, Er.r is not} > \text{Er.R}$$

The last condition is satisfied in our experiments. Much to the surprise of subjects E.B.S. and I.D.S., the evening learning was just as good as that of morning after the rest interval. F.C.D., however, demanded more exposure time to fulfil this condition and was accordingly given twenty seconds' exposure instead of fifteen, as in the case of the other two subjects.

TABLE X

	Subject: F.C.D.		
½′ Interval:	W–R = 8.3 –4.3	= 4.0	Slightly greater R. in Evening
	w–r = 7.95–3.7	= 4.25	(Diff. = 0.25)
1′ Interval:	W–R = 10.1 –4.5	= 5.6	Greater R. in Morning
	w–r = 6.5 –2.9	= 3.6	(Diff. = 2.0)
2′ Interval:	W–R = 13.5 –5.4	= 8.1	Greater R. in Morning
	w–r = 10.6 –3.6	= 7.0	(Diff. = 1.1)
	Subject: E.B.S.		
½′ Interval:	W–R = 7.9 –5.53	= 2.37	Greater R. in Morning
	w–r = 5.25–5.40	= –.15	(Diff. = 2.52—No R. in Evening)
1′ Interval:	W–R = 9.25–7.0	= 2.25	Greater R. in Evening
	w–r = 7.3 –4.75	= 2.55	(Diff. = 0.30)
2′ Interval:	W–R = 15.5 –8.7	= 6.8	Greater R. in Morning
	w–r = 12.45–7.2	= 5.25	(Diff. = 1.55)
	Subject: I.D.S.		
½′ Interval:	W–R = 8.7 –4.2	= 4.5	Greater R. in Evening
	w–r = 7.6 –1.95	= 5.65	(Diff. = 1.15)
1′ Interval:	W–R = 11.2 –5.7	= 5.5	Greater R. in Morning
	w–r = 7.8 –4.3	= 3.5	(Diff. = 2.0)
2′ Interval:	W–R = 12.1 –6.3	= 5.8	Greater R. in Evening
	w–r = 9.7 –3.2	= 6.5	(Diff. = 0.7)

The data obtained indicate that for these three trained subjects there is little or nothing to make us believe that retroaction is greater in the evening. Subject F.C.D. shows slightly greater retroaction in the evening when using the half-minute interval, but for the one- and two-minute intervals there is greater retro-

action in the morning. E.B.S. gets slightly more retroaction in the evening for the minute interval but greater retroaction in the morning for the other two intervals. I.D.S. alone gives evidence of greater retroaction in the evening, although in her case there is greater retroaction in the morning for the one-minute interval.

Our subjects are too few in numbers to permit generalization, although for each individual we have tried to make the data conclusive by securing a large number of records. As far as our evidence goes it is contrary to Tolman's notion of greater retroaction in the evening. Moreover, our results make us suspicious that the facts indicated in section (1), preceding, are due to accumulative interference systems rather than to mere fatigue accumulation.

The results of the section above and the preceding section seem in conflict. However, it must be remembered that in section (1) the subject was probably losing his incentives to learn, while in section (2), when working in the evening, the subject was thrown into a condition whereby he put forth extra effort to overcome his general fatigue condition. These differences in incentives and effort are, we believe, very complicating factors, and may explain the above mentioned differences.

Experiment Series C. Effect of Practice on Retroaction

As one becomes more and more practiced with the learning material and the methods of learning that material, does retroaction tend to disappear? Robinson (4) found no retroaction in the case of one of his subjects who was very familiar with the chess board and chess men (reconstruction test). This suggested that the fact might be due to practice.

We present the results for five trained subjects who have twenty experiments to their credit for each work and rest condition for each total interval used. We have taken the averages for the first half of the entire series and compared them with the averages for the last half of the series. The figures in parentheses give the amount of retroaction. By comparing these figures for the first and last half of the total series we should gain

some light upon the question of the relationship between practice and retroaction. The amount of retroaction should be less in the second half of the experiments in case practice decreases retroaction. It should be noted that subject F.C.D. has played chess and that E.B.S. and I.D.S. have played checkers a great deal. Consequently all knew the chess board well before beginning the experiments.

TABLE XI

COMPARING AVERAGES AND RETROACTION IN FIRST AND SECOND HALF OF EXPERIMENTS

Subject: F.C.D.

	0.5′	1.0′	2.0′	0.5′	1.0′	2.0′
	Morning			Evening		
Av. 1st 10(W)	8.9	13.9	9.1	15.9	13.0	7.3
Av. 1st 10(R)	4.4 (4.5)	3.9 (10)	5.1 (4)	2.9 (13)	2.7 (10.3)	2.0 (5.3)
Av. 2nd 10(W)	7.6	6.4	17.8	5.5	2.6	14.0
Av. 2nd 10(R)	4.2 (3.4)	5.1 (1.3)	5.7 (12.1)	4.4 (1.1)	3.0 (–.4)	5.0 (9.0)

TABLE XII

COMPARING AVERAGES AND RETROACTION IN FIRST AND SECOND HALF OF EXPERIMENTS

Subject: M.S.

	0.5′	1.0′	2.0′
	Morning		
Av. 1st 10(W)	8.9	11.3	8.9
Av. 1st 10(R)	2.6 (6.3)	4.0 (7.3)	8.0 (0.9)
Av. 2nd 10(W)	9.7	9.1	9.9
Av. 2nd 10(R)	3.5 (6.2)	8.9 (0.2)	9.5 (0.4)

TABLE XIII

COMPARING AVERAGES AND RETROACTION IN FIRST AND SECOND HALF OF EXPERIMENTS

Subject: F.Bl.

	1.0′	2.0′
	Morning	
Av. 1st 10(W)	8.3	7.3
Av. 1st 10(R)	1.3 (7.0)	1.7 (5.6)
Av. 2nd 10(W)	8.0	2.9
Av. 2nd 10(R)	1.2 (6.8)	2.4 (0.5)

TABLE XIV

COMPARISON OF FIRST AND SECOND HALF OF EXPERIMENTS

Subject: I.D.S.

	0.5′	1.0′	2.0′	0.5′	1.0′	2.0′
	Morning			Evening		
Av. 1st 10(W)	10.3	9.9	12.7	7.5	5.0	9.2
Av. 1st 10(R)	2.9 (7.4)	5.5 (4.4)	6.5 (6.2)	2.8 (4.7)	4.4 (0.6)	5.3 (3.9)
Av. 2nd 10(W)	7.1	12.4	11.4	8.0	10.6	10.2
Av. 2nd 10(R)	5.4 (1.7)	5.8 (6.6)	6.0 (5.4)	1.1 (6.9)	4.2 (6.4)	1.1 (9.1)

TABLE XV

Comparison of First and Second Half of Experiments

Subject: E.B.S.

	0.5′	1.0′	2.0′	0.5′	1.0′	2.0′
	Morning			Evening		
Av. 1st 10(W)	8.5	13.4	9.7	6.9	8.1	14.3
Av. 1st 10(R)	6.8 (1.7)	8.6 (4.8)	10.3 (–.6)	7.9 (–1)	8.3 (–.2)	9.1 (5.2)
Av. 2nd 10(W)	7.3	5.1	11.4	3.6	6.5	10.6
Av. 2nd 10(R)	3.9 (3.4)	5.4 (–.3)	7.1 (4.3)	2.9 (0.7)	1.2 (5.3)	5.3 (5.3)

If we take the total number of possible comparisons in Tables XI to XV, inclusive, we find twenty-three. Out of these twenty-three possible comparisons we find that eleven cases signify greater retroaction for the first half of the experimental series. Ten cases give more retroaction in the last half of the experiment series. Two cases are so close together that we may regard them as neutral. Looking at the comparisons by individuals, we note the following: Subject F.C.D. seems to reveal less retroaction as the experiments proceed, although in two comparisons the reverse is true. M.S. and F.Bl. seem to indicate that retroaction decreases with practice. I.D.S. and E.B.S., however, indicate that retroaction increases as the subject goes on with the experiments. In the case of the former there are four comparisons giving greater retroaction in the last half as compared to two cases where the reverse is true. E.B.S. shows the same result.

These results hardly justify us in making any definite statement as to the matter of the relationship between degree of retroaction and practice. The records of F.C.D., I.D.S., and E.B.S. are by far more significant than those of the other two subjects because they were thoroughly trained and have each six comparisons for inspection. Taking these three subjects, we find two experiencing greater retroaction in the last half of the work, while one does the opposite.

Experiment Series D. Effect of Varying the Temporal Interpolation

Müller and Pilzecker (3) and likewise Heine (2) found evidence that the sooner the interpolated work is introduced after the original learning the greater the inhibitory effects. Robin-

son,(4) however, comes to the opposite conclusion. The whole Perseveration Theory is largely at stake here, and the settlement of this point is vital to any theory of retroaction. In view of the conflicting results thus far reported it has seemed well to test further this point.

Again the reconstruction test has been used as original learning material. The total length of the interval between learning and attempted reconstruction has been kept constant. The only varying factor was the temporal position of the interpolated work.

The experiments fall into two different series as follows (figures represent minutes in all cases):

Series I. Total interval 10 mintes:

Method I. Learn—Work 3—Rest 7—Reconstruct.
Method II. Learn—Rest 3—Work 3—Rest 4—Reconstruct.
Method III. Learn—Rest 5—Work 3—Rest 2—Reconstruct.
Method IV. Learn—Rest 7—Work 3—Reconstruct.

Series II. Total interval 5 minutes:

Method I. Learn—Work 2—Rest 3—Reconstruct.
Method II. Learn—Rest 1—Work 2—Rest 2—Reconstruct.
Method III. Learn—Rest 2—Work 2—Rest 1—Reconstruct.
Method IV. Learn—Rest 3—Work 2—Reconstruct.

Series II was done after series I because the first results were rather unsatisfactory so far as indicating anything definite was concerned. In the first series we used multiplication of two by four place numbers as the work. This work was unsatisfactory because it became automatic too readily and appealed very little to the interest of the subjects. Consequently in series II, in addition to reducing the total time to five minutes, algebra problems took the place of the multiplication. These problems were simple equation problems with which the subject could make headway in the short work time.

On any day's sitting the subject was given all the various methods, there being a rest of from two to four minutes between each experiment. To equalize the fatigue factors the methods were rotated from day to day. In series I, E.B.S. alone did all four methods listed above; the others did three.

Nine trained and ten untrained subjects participated in this experiment. Tables XVI and XVII give the individual averages for the trained subjects for both series I and II. Table XVIII gives the averages for the untrained subjects. Graphs I and II will give the same facts for the trained subjects as found in their tables.

SUMMARY TABLE XVI

Showing Averages for Five Trained Subjects. Effect of Varying Rest Interval Between L and W, Reconstruction Test, Series I

	W 3 R 7		R 3 W 3 R 4		R 7 W 3		R 5 W 3 R 2	
Subject	Er.	T.	Er.	T.	Er.	T.	Er.	T.
Deus.	12.60	99.6	7.10	91.0	7.9	11.40	....	....
F.C.D.	8.47	58.5	8.00	51.9	6.1	62.7	....	....
I.D.S.	11.20	72.5	5.95	63.3	10.0	75.0	....	....
M.S.	10.90	122.5	10.60	121.6	11.8	116.6	....	....
E.B.S.	12.40	89.9	9.70	82.5	9.3	74.3	5.4	21.5
Total	55.57	443.0	41.35	410.2	45.1	442.6	5.4	21.5
Mean	11.11	88.6	8.27	82.0	9.0	88.5		

SUMMARY TABLE XVII

Showing Averages for Four Trained Subjects. Effect of Varying Rest Interval Between L and W, Reconstruction Test, Series II

	W 2 R 3		R 1 W 2 R 2		R 2 W 2 R 1		R 3 W 2	
Subject	Er.	T.	Er.	T.	Er.	T.	Er.	T.
F.Bl.	3.13	21.2	1.73	24.7	3.60	24.9	2.53	29.7
E.B.S.	12.00	73.1	7.30	61.6	8.87	66.6	6.00	76.0
I.D.S.	9.87	62.0	8.00	56.7	7.47	52.8	8.87	58.7
R.S.	10.91	74.4	10.50	71.4	8.83	86.9	9.00	75.0
Total	35.91	230.7	27.53	214.4	28.77	231.2	26.40	239.4
Mean	8.98	57.7	6.88	53.6	7.19	57.8	6.60	59.9

TABLE XVIII

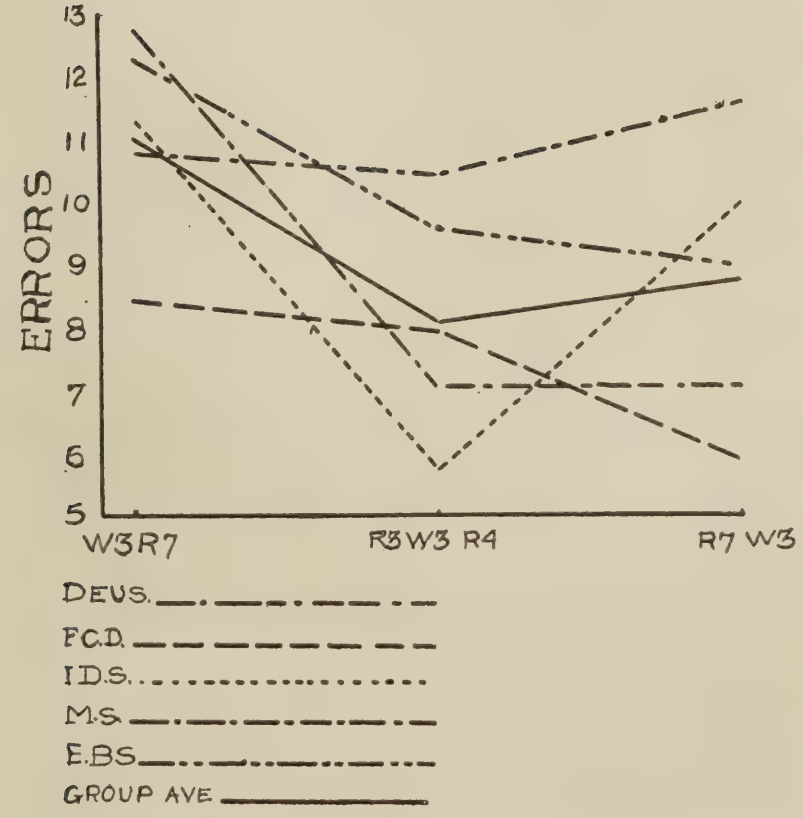
Showing Average Time and Errors for Untrained Subjects. Effect of Varying Rest Interval Between L and W. Based upon Four Records Each. Series II

	W 2 R 3		R 1 W 2 R 2		R 3 W 2	
Sex	Er.	T.	Er.	T.	Er.	T.
Female	5.50	68.5	5.00	56.3	5.80	120.5
Female	1.50	44.0	4.75	36.3	5.75	24.0
Female	6.75	45.8	5.25	42.5	2.00	47.8
Female	5.75	22.3	4.50	50.8	13.50	48.3
Female	8.75	81.7	12.50	90.0	17.5	125.0
Female	11.50	35.8	6.00	51.0	7.5	42.5
Female	15.25	61.5	8.25	35.3	3.5	50 7
Male	13.00	23.0	7.75	26.5	9.0	21.0
Male	2.00	49.0	2.00	52.0	2.0	65.0
Female	3.20	41.6	1.60	25.8	4.6	64.0
Total	73.2	473.2	57.60	466.5	71.15	608.8
Mean	7.32	47.3	5.76	46.7	7.12	60.9
M.V.	3.84	14.3	2.29	13.5	3.83	26.2

Turning first to the averages presented in the foregoing table for series I, we note that most errors are made when the work is introduced immediately after the original learning. However, comparing methods II and IV, we find that the former gives the less number of errors. We cannot account for this unless the work, coming at the end of the interval and thus just before the reconstruction, leaves the subject in an attitude which is unfavor-

GRAPH I

FROM TABLE XXXIV

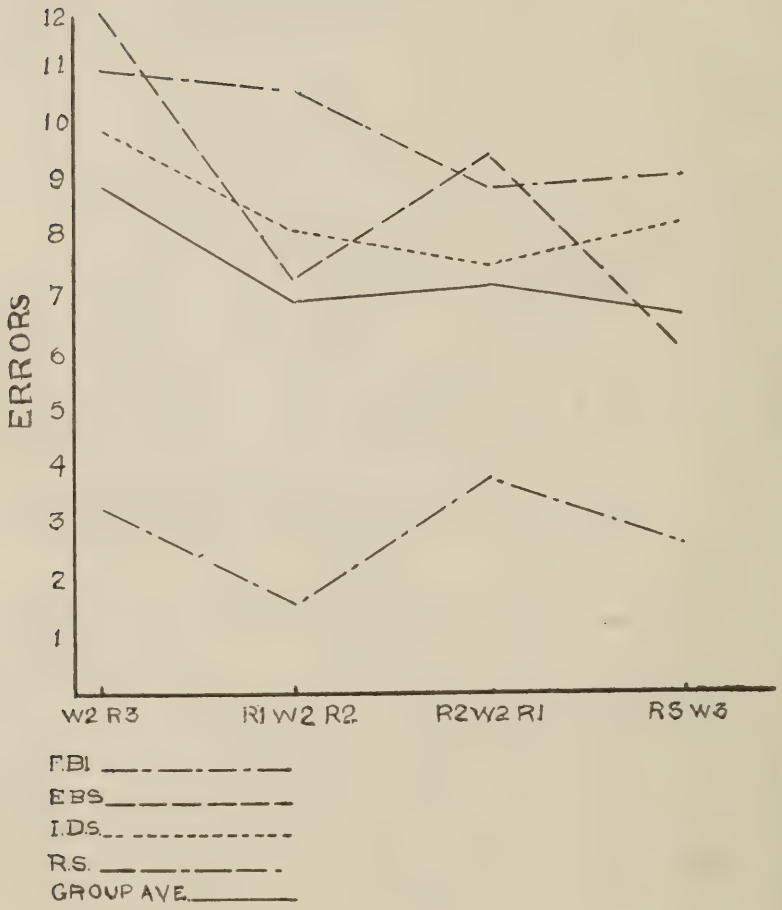


able to recall. Heine (2) found that this difference in attitude was insignificant in the case of nonsense syllables. Also, we have found very often that the subject was " farther away " after a rest than after a work interval, and our experiment testing the above assumption gave no evidence in its favor.

Considering individual performances, which is more important

GRAPH II

FROM TABLE XXXV



here perhaps, we find that F.C.D. gives a nicely graded series (see Graph I). His results fit the perseveration view nicely. E.B.S. has a similar curve, although the differences are not so marked between the various methods. The other subjects all show more errors when the work is introduced immediately but, peculiarly enough, get their best results by the intermediate method.

If we now inspect series II (see Summary Table XVII and Graph II, above), we find, comparing the extreme methods, W2 R3 and R3 W2, that the group average shows more errors when the work is introduced immediately. However, we again fail to secure a graded series, reading from left to right in our summary table or graph, as we might expect if the perseveration view is correct and our methods adequate. A study of the individual records shows clearly that the temporal position of the interpolated work is significant—the " work-at-once " method is the poorest.

A study of Table XVIII, giving the results for the untrained subjects, indicates likewise that the temporal position of the work is important. The most errors are made when the work is introduced immediately after the original learning.

Experiment Series E. The Degree of Similarity Between Interpolated Work and Original Learning

What is the relation between the degree of similarity of work interpolation and original learning as regards the amount of retroaction? Robinson (4) found evidence that retroaction is a function of the similarity between interpolated work and learning. Certainly the problem is a vital one from the standpoint of a theory of retroaction. If the work and original learning are identical, then we have mere repetition, and consequently mere reinforcement of the impression value and the associative bonds. But as the work becomes more and more dissimilar in content and method, where do we find a place where reinforcement stops and interference begins? Obviously two difficulties of experimentation appear. We must work out *a priori* a graded series

of work activities ranging from identical to dissimilar. Also we must see to it that these various work activities are equally taxing, equally interesting and absorbing. Both desiderata are difficult to attain.

In the following experiment series we have tried to obtain further facts upon this problem of degree of similarity. Two series of experiments were carried on (I and II below). As these two series differed considerably we will take them up separately:

Series I

The reconstruction test was used as in previous experiments. The variable factor was the content of the interpolated work. The following outline will give the plan of procedure:

(a) S. studies the chess men arrangement for fifteen seconds. This we designate simply the original learning.
(b) S. rests one minute. E. arranges the work series.
(c) S. studies the interpolated work for fifteen seconds. The content of this work was the varying factor.
(d) S. rests for one minute.
(e) S. is tested for thirty seconds on the interpolated work or else continues the work if it is multiplication. In case of reconstruction type of work, S. tries to reconstruct. In case of picture study, S. tries to recall all details. If S. finished the reconstruction or the recall of the picture details before the thirty seconds were up (this seldom ever happened) he continued to think over what he had just done.
(f) S. rests one minute. E. records the score made on the work and makes ready for the reconstruction of the original learning.
(g) S. tries to reconstruct the original chess formation.

The work material consisted of four varieties for all subjects, excepting I.D.S. and E.B.S., as follows:

I. Similar work. Here S. studied a new chess formation and after one minute tried to reconstruct it.

II. Intermediate form of work. A plain white cardboard was inked in heavy black lines such as to make sixty-four squares. This card exactly covered the chess board and was placed upon it during the work. Five articles were arranged upon these squares, namely, a large white button, large black button, a red checker, a black checker, and a pawn. S. studied this formation and later tried to reconstruct it. Our assumption is that this work has some similarity to the original learning and yet differs in certain respects.

III. Multiplication of two by four place numbers. Some subjects added double columns of figures instead, as the multiplication became automatic.

IV. Study of post card pictures of scenery. Here S. was told to study the pictures with the purpose of later recalling all possible details. These last two forms of work we have thought of as dissimilar and so signified in the following tables.

Three to four minutes intervened between each experiment. A day's experimentation included all four (or three, as the case might be) kinds of work. For I.D.S. and E.B.S. six chess men were used in the work series involving reconstruction work, whereas only five men were used for the other subjects. The order of presentation was rotated from day to day. The subject only rarely knew what kind of work was coming next.

The tables giving averages for this experiment series follow (Tables XIX and XX). Table XLIII is a summary table for nine untrained subjects.

If we will now compare the average error (Table XIX) for either of the dissimilar series (multiplication, or addition, on one hand, or picture study on the other hand) as over against the average error for the similar series, we note that the group means indicate that there is more retroaction where the work is similar. The reconstruction times show nothing. If we take the individual cases, as such, however, we find disagreement. If it is true that retroaction is a function of the degree of similarity, and if we really have three kinds of work differing in degree of

SUMMARY TABLE XIX

DEGREE OF SIMILARITY, SERIES I, RECONSTRUCTION TEST. TRAINED SUBJECTS

	I. Similar		II. Intermediate		III. Dissimilar (Adding)		IV. Dissimilar (Picture)	
Subject	Er.	Time	Er.	Time	Er.	Time	Er.	Time
F.C.D.	10.17	49.7	3.42	47.8	5.93	37.3	6.63	44.9
R.M.B.	10.70	62.1	11.90	66.4	9.80	91.9	15.38	65.4
I.D.S.	15.42	80.9	7.92	59.3	6.67	47.3	....	....
E.B.S.	13.17	53.8	11.25	63.2	9.83	74.1	....	....
R.S.	15.80	65.6	11.70	64.1	16.50	71.5	13.50	62.1
Total	65.26	312.1	46.19	300.8	48.73	322.1	35.51	172.4
Mean	13.05	62.4	9.24	60.2	9.75	64.5	7.1	34.5

EXPLANATORY NOTE.—Averages given based upon 11 records for F.C.D., 10 for R.M.B., 12 for I.D.S., 12 for E.B.S., and 10 for R.S. The times of day when experiments were given were: 8:00 A.M., F.C.D.; 11:30 A.M. for R.M.B.; 7:00 P.M., I.D.S. and E.B.S.; 7:00 P.M., R.S.

TABLE XX

RECONSTRUCTION TEST. DEGREE OF SIMILARITY, SERIES I. SHOWING AVERAGES FOR 9 UNTRAINED SUBJECTS, BASED UPON 5 RECORDS EACH

	Similar		Intermediate		Dissimilar	
Sex	Er.	Time	Er.	Time	Er.	Time
Female	15.0	53.6	12.2	81.0	4.0	59.4
Male	14.8	80.2	9.8	42.8	13.2	36.2
Female	14.4	57.6	9.8	34.8	7.4	39.0
Female	11.8	61.6	6.2	56.4	9.8	56.2
Female	11.8	48.8	6.0	32.8	4.2	34.2
Female	12.0	93.5	13.0	105.2	4.6	66.2
Female	9.0	50.5	9.0	40.5	7.8	32.6
Male	7.0	35.5	7.75	32.0	6.5	23.5
Female	7.2	55.4	4.6	39.4	4.6	35.6
Total	103.0	536.7	78.35	464.9	62.1	382.9
Mean	11.44	59.6	8.7	51.7	6.1	42.5
M.V.	2.48	13.2	2.28	19.5	2.33	12.0

similarity, then our summary table should show a decreasing average error as we read across from left to right. Method I, Similar, should give the greatest error; Method II, Intermediate, should give less errors; Method III, Dissimilar, should give least error. Unfortunately for such nicety of results, this is neither true for the group averages nor for individual means. F.C.D. shows least errors for the Intermediate method, although he makes most errors where the work is similar. I.D.S. and E.B.S. give results according to expectations stated above. R.M.B. gives a medley of results. He makes far more errors after studying the pictures than after any other kind of work; then in decreasing order of errors we find: Intermediate, Similar, and Dissimilar (adding). R.S. gives a similar irregularity of results.

Table XX, the summary table for the untrained subjects, indicates that the similar work causes greater interference than the dissimilar. In fact, their table gives a nicely graded series of errors, as we might expect. This is true for both time and errors.

Our data seem fairly indicative of the importance of the degree of similarity and in so far confirm Robinson's results.

Series II

Feeling that there was the possibility that the different kinds of work used in the previous series might have involved different degrees of effort and attention, an additional series of experiments were done. Also we were urged to carry out these additional experiments to test further the matter of finding the point where similarity ceases to be conducive to retroaction and turns into actual facilitation. Consequently in these experiments we have confined ourselves entirely to the reconstruction test both for the original learning and the work. According to the decreasing degree of similarity as we deduced it, three different work arrangements were used, indicated in the following tables as I, II, and III. Work formation I was very similar to the original arrangement excepting that the chess men were removed in any direction by one square (in a few cases by two squares). Work arrangement II involved the using of the same squares as in the original learning (thus keeping the same pattern) but different men on these squares. We have considered this arrangement as intermediate. Work formation III consisted in as widely different arrangement of the chess men with regard to the original formation as was possible. Thus if the original formation had the men clustered together, in the work they were widely scattered. This we have considered as the least similar work arrangement.

The procedure was similar to that in Series I. Five trained subjects did the experiments. On a given experiment day all three experiments were done twice, with an interval of from three to four minutes between each. Table XXI gives the individual averages.

SUMMARY TABLE XXI

DEGREE OF SIMILARITY, SERIES II, RECONSTRUCTION TEST. TRAINED SUBJECTS

	I			II			III		
Subject	Er.	Time	Er.W.	Er.	Time	Er.W.	Er.	Time	Er.W.
F.C.D.	3.2	35.1	5.7	6.7	14.0	11.8	10.6	51.8	14.0
R.M.B.	9.5	50.9	6.4	18.6	58.9	7.5	11.0	45.1	10.6
I.D.S.	5.8	74.6	3.1	10.1	66.0	3.0	11.9	57.6	4.4
E.B.S.	8.3	42.0	5.1	5.9	41.9	6.7	12.6	73.1	5.9
R.S.	13.6	70.4	6.3	5.7	58.8	5.1	12.4	63.7	10.2
Total	40.4	273.0	26.6	47.0	239.6	34.1	58.5	291.3	45.1
Mean	8.08	54.6	5.32	9.4	47.9	6.82	11.7	58.3	9.02

NOTE.—Following are given the times of day and (in parentheses) the number of records upon which each average is based: F.C.D., 8 A.M. (10); R.M.B., 11 A.M. (10); I.D.S., 7 P.M. (10); E.B.S., 7 A.M. (10); R.S., 7 P.M. (10).

Taking the mean of the group of five subjects, we find that the just slightly dissimilar Series I gives the least mistakes both for the reconstruction of the original learning (note column headed Er.) and for the reconstruction of the work series (see column headed Er.W.). Our so-called Intermediate Series II stands intermediate as regards both sets of error values. Series III, the most dissimilar series, gives MOST mistakes. It is of interest to note that there is an apparent relationship between mistakes in the original learning and the work series. A glance at the summary table shows that the smaller the error for the original learning, the smaller the error for the work, and *vice versa*. This may be indicative of interinhibitory or interference processes working backward and forward. Subjects F.C.D. and I.D.S. show a nicely increasing error value through Series I, II, and III. The increasing order of errors for R.M.B. is I, III, II; for E.B.S., II, I, III; for R.S., II, III, I.

From the standpoint of similarity of individual results our data are not satisfactory. The group mean, however, indicates that the most dissimilar work gives the greatest retroaction. Most of the subjects realized at once, in Work Series I, the fact that the change was slight. Here we approximated a mere repetition—at least definite relationship cues were present in the work arrangement which actually reinforced at times the original learning. Consequently we could hardly expect S. to make many mistakes. In Case II it was different. Although the same squares were covered as in the original learning, the chess men were rear-

ranged on these squares. This tended to bring confusion. The subject realized at once that he was dealing with the same pattern but the complete changing about of the chess men in some way brought confusion. In Case III the work arrangement was as different from the original as possible and so appreciated by the subject.

The introspective aspect of this experiment series has been especially elucidating and suggestive. On the basis of these introspections and the above tables we may venture the following conclusions and interpretations:

(1) Least errors were made in Work Series I. This was because the similarity approximated identity too closely, permitting helpful relationships to be easily noted. This is another way of saying that we had enough identical elements (largely in the form of spacial contiguity) to afford a positive transfer effect, however small.

(2) The Method II was intermediate in errors. This was so because it stood intermediate between helpful similarity (as noted in (1) above) and harmful degree of dissimilarity, as was found in Method III. It offered a greater degree of dissimilarity than Method II, there being less chance to note helpful similarities and differences. On the other hand, there must have been some few helpful relationships in this method because it was not so destructive of retention and recall of the original learning as was Method III.

(3) Method III gave most errors. Here the point of helpful relationship between work and learning (at least the point of relatively harmless relationship) is definitely passed and the work acts detrimentally.

(4) If we make up a series of apparently varying degrees of SIMILAR work, all series of which use the same material and methods of learning as the original learning, then the MORE DISSIMILAR the material the greater the retroaction.

(5) We feel that the above is in no way contradictory to the facts found by Robinson or the results found in our preceding Series I. As Robinson has suggested, if we begin with original learning and work interpolation as identical, then there will be,

of course, reinforcement, a mere repetition. As the work is made more and more different, there comes a time when the reinforcing factors drop out or give way to interfering factors. Let us call this point, just mentioned, Point C. Up to Point C our statement above holds good. Here the greater the similarity the MORE the reinforcement and the LESS the interference. But as we go past this Point C the whole situation becomes reversed, and the more similar the material and method in the work the greater the retroaction, granting equality of attention and effort. This conception of the matter may be put in diagramatic form as shown in Diagram I.

DIAGRAM I

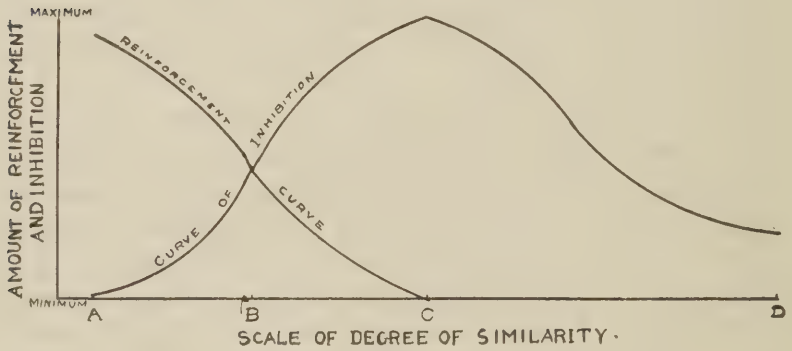


FIGURE 3. *Explanatory Note.*—The above diagram is merely theoretical in its outline. Possibly the curves may be drawn with some mathematical precision in the future. The scale on the left vertical represents the amount of reinforcement and retroaction—two opposed processes. The horizontal scale represents the degree of similarity between the original learning and the interpolated work. Beginning at A where learning and work are identical, as we go to the right there is greater and greater dissimilarity until at D the two are as dissimilar in content and method as is possible. At A inhibition is at a minimum and reinforcement at a maximum (mere repetition); at C the situation is reversed. At D the inhibition curve has fallen but never to the original minimum.

Experiment Series F. Qualitative: Nature of the Rest and Work Intervals

In Part I, Experiment Section preceding, we noted that the validity of our results rested largely upon the nature of the work and rest intervals. However, it is extremely difficult to secure

many " ideal " rest intervals—ideal in the sense that the subject was mentally passive and indifferent and entirely away from the original learning material. If one can secure ten such intervals out of twenty experiments, one is lucky. In a preceding section (see Table VII) we selected those experiments where the rest interval was characterized by practically no consciousness of the original learning after the after-image had faded away. No attention was paid as to whether or not the subject was " active " mentally along other lines. A glance back at Table VII shows the proportion of " ideal " rest intervals to the total of the rest intervals. In the case of the half-minute interval we note that there are 56 ideal rest intervals out of a total of 120; in the minute interval there are 51 ideal rest intervals out of 120; and in the two-minute interval there are 41 ideal rest intervals out of 120. Obviously, as the rest interval is lengthened there is a smaller proportion of " ideal " rest intervals. We found that ten- and fifteen-minute intervals were not only conducive to all sorts of mental activity on the part of our subjects, but they tended to put a premium upon thinking about the original learning. For this reason we have not used long intervals in this investigation.

It must be remembered that an " ideal " rest interval meant no return to consciousness of the original learning. If we would include those intervals where the subject reported merely a vague and indefinite and fleeting consciousness of the learning, our number of " ideal " rests would then be much larger. The cases where a complete " return " of the whole learning came to mind were very few. The consciousness of the original learning thus ranged from a mere fleeting and fragmentary visual or subvocal representation to a review of the whole situation. In general, we may say that as the subject progressed with the experiments he was better able to take an indifferent attitude during the rest intervals. There was always a memory after-image which faded out in the course of one to three seconds.

All subjects reported at times that they felt that the learning material was " near at hand " and ready to " break in." F.C.D. was the subvocalizer of the group. Often the subject would

report that a mere visual image of one or more chess men would flash into mind and out again without being connected with any chess board. At times a part of the chess board or the whole of it would flash into mind without any men placed upon it. Whether these fragmentary and isolated forms of consciousness were any aid toward retaining the original learning is difficult to say. We would hazard a guess that in many cases they were not an aid but actually a hindrance. At times pictures of previous chess formations would come to mind, and most of the subjects felt (rightly or wrongly) that these were a hindrance to them.

In the work interval the subjects seldom ever reported any return to consciousness of the original learning. The after-image or memory after-image was usually cut short in the work intervals. If the work became automatic, then the subject tended to think of the learning or wander off into more interesting fields. On the whole our subjects reported that the work kept them busy.

We may here anticipate the introspective results for the nonsense syllable experiments following by saying that the rest intervals were much freer from any consciousness of the original learning than was the case with the reconstruction test. The sense words were more inclined to return to consciousness than either the reconstruction test material or the nonsense syllables.

PART III. EXPERIMENTAL SECTION

SERIES OF TWELVE SENSE WORDS AS ORIGINAL LEARNING

Will the same results found in the case of the reconstruction test likewise be found in the case of sense words? The following experimental section attempts to answer this question. In all the experiments reported in this section it is to be understood that the original learning consisted in a series of twelve sense words. The words were all one syllable, common words of three, four, and five letters (in a few cases six letters). The great majority of words were nouns, some verbs, and relatively few adjectives and adverbs. As far as possible the words in any one series were so chosen as to have little obvious relation between them. In all series the words were arranged in succession, according to number of constituent letters, as follows: 4, 4, 4, 5, 3, 4, 5, 5, 3, 4, 5, 4. As can be seen, the four-letter words predominated. The same instructions were given the subjects concerning the work and rest intervals as stated in the last section.

Experiment Series A. Comparison of Work versus Rest Intervals

For various reasons, as will be mentioned later, this series of experiments falls into three groups, (1), (2), (3).

Group (1)

Two trained subjects did these experiments. The sense words were printed in large black typewritten type on 3″ x 5″ cards. They were exposed serially and at the rate of one per 1.5 second by moving a long covering cardboard, containing a small lateral window cut into it, down the card. A silent swinging pendulum beat the time.

The words were exposed just once, as we desired to secure but a faint impression. The words having been exposed, there

followed a work or a rest interval, as the case might be. The work consisted in adding ten one place numbers as fast and accurately as possible. One- and two-minute intervals were used. On any given experiment day six experiments were done, that is, three involving work and three involving rest intervals. Two minutes' time elapsed between each experiment. Each day the order of the experiments was reversed, to-day being R, W, R, W, R, W, next time W, R, W, R, W, R. Each subject knew what kind of interval was coming next. The two subjects alternated in giving each other the tests, each subject doing his or her experiments every other day (9 A.M.).

The following table gives the averages based upon twenty experiments for each work and rest interval, employing both one- and two-minute periods. Large R at the head of the column stands for the total number of words correctly recalled. Er. represents words recalled but which were incorrect. T signifies the time for recall. Figures in parentheses give mean variations.

TABLE XXII

	One Minute Interval						Two Minute Interval					
	Work			Rest			Work			Rest		
	R	Er.	T.	R	Er.	T	R	Er.	T	R	Er.	T
I.D.S.	3.9	0.4	88.2	5.4	0.6	82.8	3.1	0.45	97.0	5.2	0.8	79.2
	(1.2)	(0.5)	(24.0)	(1.1)	(...)	(17.8)	(1.4)	(0.54)	(21.6)	(0.9)	(0.8)	(16.1)
E.B.S.	2.9	0.3	75.6	3.2	0.7	70.7	2.3	0.40	72.3	2.2	0.4	72.6
	(1.1)	(0.4)	(18.0)	(1.3)	(0.8)	(16.5)	(1.3)	(0.5)	(12.9)	(1.0)	(0.5)	(14.2)

Inspection of the table shows clearly a retroaction in the case of I.D.S. Subject E.B.S. indicates a slight tendency toward retroaction in the minute interval, whereas in the two-minute interval no retroaction is found.

Group (2)

This group of experiments differs from the last in a number of respects. First, the order of presentation was irregular, and consequently S. did not know what interval was coming next. Second, only one interval was used, namely, a three-minute period. Third, S. worked only one minute, resting the last two

minutes before recall. Fourth, two exposures were given instead of one. Fifth, the words were presented by a memory apparatus.

The exposure apparatus used was a modification of the older Wirth machine made by Professor J. F. Shepard at the University of Michigan. The series of sense words were written upon a strip of white paper in the same way as above mentioned. This strip was placed on the rotating drum of the machine and each word exposed serially at the exposure window. As there were fourteen stops during a complete drum rotation, and as we employed only twelve words, there was therefore an exposure of two blank spaces between the two exposures.

The words were exposed serially at the rate of 1.5 second each, two exposures being given. The total exposure time was thus three seconds for each word. Each word was spoken aloud by S., who was instructed to take a discouraging attitude toward forming connections between the words. Other conditions were as in Group (1).

Four trained subjects did these experiments. Table XXIII gives the means and mean variations (latter in parentheses). The averages are based upon nine experiments for each work and rest interval for all subjects excepting R.M.B., who has ten records.

TABLE XXIII

Subject	Work R	Work Time	Work Er.	Rest R	Rest Time	Rest Er.	Hour of Experiment
Shps.	7.0	77.4	0.3	7.25	73.2	0.78	11 A.M.
	(1.7)	(30.4)	(0.4)	(1.53)	(16.7)	(0.52)	
R.S.	4.89	66.2	0.8	5.89	71.6	0.30	2:30 P.M.
	(2.1)	(17.3)	(0.8)	(1.26)	(9.5)	(0.5)	
R.M.B.	5.1	82.5	0.2	4.89	65.1	0.66	11 A.M.
	(1.2)	(29.1)	(0.3)	(1.0)	(22.1)	(0.6)	
M.Blf.	5.78	48.6	0.8	6.10	50.3	0.78	1:30 P.M.
	(1.63)	(15.1)	(0.7)	(1.23)	(16.1)	(0.69)	
Total	22.77	274.7	2.1	24.13	260.2	2.52	
Mean	5.69	68.7	0.5	6.02	65.0	0.63	

The above table indicates, in the case of three subjects, some retroaction. However, the difference between rest and work intervals was small, while in the case of R.M.B. the rest interval was more unfavorable to retention and recall. While we may say that some retroaction is indicated here, the results are not

striking. The suggestion arose early that perhaps our work interval was too short. In consequence of the poor results obtained above, these experiments were discontinued and a third group begun.

Group (3)

The following experiments are exactly similar to the above in all respects except that the work was extended over two minutes instead of one. Thus we have two experiments:

(a) The Work Series: Learn, work 2 min., rest 1 min., recall.

(b) The Rest Series: Learn, rest entire 3 min., recall.

The following table gives the means and mean variations for three trained subjects. All averages are based upon twelve experiments each for the work and rest conditions excepting in the case of F.C.D., who has fifteen records.

TABLE XXIV

Subject	Work R	Work Time	Work Er.	Rest R	Rest Time	Rest Er.	Hour of Experiment
F.C.D.	5.33	60.5	0.33	6.07	56.5	0.2	8:20 A.M.
	(1.51)	(11.9)	(0.53)	(1.41)	(12.8)	(0.34)	
R.S.	4.66	79.1	0.08	5.16	81.1	0.33	2:30 P.M.
	(1.56)	(12.9)	(0.15)	(1.39)	(8.81)	(0.44)	
M.Bl.	4.92	63.1	0.5	6.17	63.8	1.0	1:30 P.M.
	(1.11)	(10.3)	(0.6)	(1.19)	(11.9)	(0.8)	

In all cases in the table above we find that R for the rest condition is greater than R for the work condition. The rough time measurements signify nothing. Likewise a study of the errors made shows nothing definite.

The experiments were also made upon five untrained subjects, students just finishing their first semester in the elementary laboratory course. They were given twelve experiments, six for each condition. Their averages are given in the following table. No mean variations are given.

TABLE XXV

Subject	Work R	Work Time	Work Er.	Rest R	Rest Time	Rest Er.	Hour of Experiment
R.M.	3.67	78.2	0.67	3.33	86.7	0.50	9 A.M.
H.G.	5.33	84.7	0.17	7.00	67.0	0.30	4 P.M.
L.B.	5.58	92.8	0.25	5.58	80.2	0.40	11 A.M.
G.J.	5.00	69.9	0.67	7.00	69.0	0.67	1:30 P.M.
E.D.	3.20	43.4	0.00	2.80	49.0	0.20	4 P.M.
Total	22.78	369.0	1.76	25.71	351.9	2.07	
Mean	4.56	73.8	0.35	5.14	70.4	0.42	

Two subjects do better after the work, two better after the rest, while one does the same in each, as regards R. The averages for the group indicate a retroactive inhibition. While these results are not convincing, they indicate, if we take the group average, some detrimental influence.

Experiment Series B. Effect of Practice

In the table below we have summarized the averages for the first and last halves of three subjects' completed records. The results are taken from a study of the individual records whose means are given in Table XXIV, preceding.

TABLE XXVI

Subject	Position in Series	Work R	Rest R	Retroaction (Rest–Work)
M.Blf.	First Half	4.83	5.2	0.37
	Last Half	5.00	7.2	2.20
F.C.D.	First Half	4.86	5.6	0.74
	Last Half	5.60	6.70	1.10
R.S.	First Half	5.50	4.83	–00.67
	Last Half	3.83	5.50	1.67

If we measure the amount of retroaction by the formula, R rest minus R work gives the amount of retroaction (where R stands for the amount recalled), then we find, in the case of the above named subjects, that as they become more practiced in the tests retroaction increases. This is true in every case. As our practice period is at most rather short, we can only say that within the limits of practice involved in our present experiments the retroaction became more marked as the practice increased. This is possibly due to the fact that our subjects constantly improved in ability to take an indifferent and passive attitude in the rest period.

Experiment Series C. Position of Experiment in a Day's Experiment Series

If we take the rest and work intervals which occur in the first part of the day's experimental series and compare the retroaction thus found with the retroaction found between work and rest intervals occurring in the last part of the day's series, what

do we find? It will be remembered that a day's experiment series consisted of six individual experiments. We have gone through the results for three subjects, whose means are given in Table XXVII, thus making the comparisons above stated. The following table gives the results:

TABLE XXVII

Subject	Position in Series	R Work	R Rest	Retroaction (R rest–R work)
F.C.D.	First Half	5.78	6.17	0.49
	Last Half	4.67	5.94	1.27
R.S.	First Half	5.00	5.60	0.60
	Last Half	4.20	4.86	0.66
M.Blf.	First Half	4.70	7.00	2.30
	Last Half	5.17	5.33	0.15

The data are not uniform in indication. In the case of F.C.D. there is more retroaction for those experiments occurring near the end of the day's series. The difference is marked and corresponds to his introspections where he believes that he gets worse as the experiments progress in a given sitting. The record for R.S. shows nothing. On the other hand, M.Blf.'s record shows that there is more retroaction for those experiments occurring at the beginning of the day's series. About all we can say is that we have found individual variation in this regard.

Experiment Series D. Effect of Temporal Interpolation

The method of presentation and material were as stated in Experiment Series A, Group (1), with certain changes. A short exposure or learning was again used, the series of words being presented two times. The work consisted in solving simple equation algebra problems. The total length of time between learning and the attempted recall was kept constant in all cases, namely, five minutes. The variable condition is the temporal position of the work. Four different conditions were used, as follows:

(1) L–R3–W2 ..... Recall
(2) L–R2–W2–R1 ..... Recall
(3) L–R1–W2–R2 ..... Recall
(4) L–W2–R3 ..... Recall

All four experiments were done at one sitting, four minutes elapsing between the end of one experiment and the beginning

of the next. The experiments were rotated from day to day. Excepting in the case of the last experiment of the day, the subject did not know, or very seldom, what kind of experiment was next. Unfortunately, only two subjects did this work, namely, I.D.S. and E.B.S., but for these two subjects the experiments were continued until their significance was clear.

If the perseveration view is correct, and our work really involves a good type of concentrated activity, then we should theoretically expect to find least recall when the work followed immediately after the learning; then more recall for Method (3), more yet for Method (2), and most words recalled for Method (1), where we rest for three minutes after learning.

The following table gives the results. The averages are based upon twelve experiments for each of the four different conditions. Experiments were done at 9 A.M. The figures in parentheses give the mean variations.

TABLE XXVIII

	R3 W2			R2 W2 R1			R1 W2 R2			W2 R3		
	R	Er.	T	R	Er.	T	R	Er.	T	R	Er.	T
E.B.S.	3.92	0.5	90.0	3.33	0.25	89.5	3.33	0.08	72.6	1.5	0.17	83.2
	(0.65)		(20.0)	(1.38)		(13.0)	(1.67)		(13.6)	(1.0)		(14.8)
I.D.S.	3.66	1.8	90.3	4.08	1.00	86.1	4.08	1.30	88.3	4.8	0.83	74.7
	(1.47)		(21.8)	(1.10)		(17.4)	(1.75)		(28.3)	(1.8)		(18.7)

Examination of these results shows diametrically opposed results. The record of E.B.S. is in accord with what we might theoretically expect from the standpoint of a perseveration view. The results of I.D.S. would indicate that she does best when the work is introduced immediately. However, the differences between the various methods are all very small and the safest thing to say is that this subject does not experience any greater retroaction when the work follows immediately.

PART IV. EXPERIMENTAL SECTION

NONSENSE SYLLABLES AS ORIGINAL LEARNING MATERIAL

The following experiments attempt to give some light upon the same problems raised in the preceding experimental sections. However, in this section we have used nonsense syllables for the original learning. Nonsense syllables were used in one or the other of two forms, either as series of seven single syllables or as a series of seven paired syllables. Syllables having obvious meanings were thrown out. In any series we attempted to secure a balanced series of syllables with regard to difficulty of pronunciation. No two syllables in a given series began or ended with the same letter and no two syllables had two similar letters in order, as JEC, LEC.

Experiment Series A. Using Single Syllable Series. Comparison of Rest versus Work Intervals

The Shepard exposure apparatus, previously mentioned, was used. Seven nonsense syllables were typewritten in black large sized type upon a strip of white paper which was placed upon the drum of the exposure machine. As there were fourteen stops in a complete drum rotation, and inasmuch as we used only seven syllables, they were so arranged that every other stop of the drum gave a blank exposure. Each syllable was thus exposed for one second, then followed by a blank exposure; then the next syllable was exposed for one second, and so on. The tempo of the presentation was controlled by a silent swinging pendulum. The subject pronounced each syllable aloud once as it was presented. The syllables were exposed three times.

After the exposure the experiment might take either of two forms, as follows: (1) a rest series of three minutes' duration or (2) a work series, consisting of two minutes of concentrated work on mathematical or reasoning problems, such as the Thurs-

tone series A and B; then subject rested one minute. The minute of rest, following the work, was used to give the subject a chance to rest and also to get away from the "work attitude." The subject then tried to recall all syllables possible.

At one sitting six experiments were performed, three involving work and three involving rest intervals. Between two and three minutes elapsed between each experiment. Subjects I.D.S. and E.B.S. alternated every other night as subjects in these experiments. The other subjects performed twice a week.

The following tables give the averages for five trained subjects and fourteen untrained subjects. R stands for the number of correct reproductions; Er. for the errors; and T for the time of reproduction (taken with a stop watch). Half credit was given if two letters, in their proper sequence, were reproduced, as HIG for LIG. The time represents the interval between the signal for recall and the final statement of the subject that no more syllables would come (S. was asked not to "rack his brain" for the syllables). Again introspections have been carefully taken.

TABLE XXIX

SHOWING AVERAGES AND MEAN VARIATIONS FOR FIVE TRAINED SUBJECTS. SERIES A, SINGLE SERIES NON-SENSE SELLABLES. REST VS. WORK INTERVALS

	Work Interval			Rest Interval		
Subject	R	T	Er.	R	T	Er.
I.D.S.	3.31	72.4	0.54	4.23	82.2	0.54
	(1.15)	(16.1)	(0.48)	(0.66)	(18.7)	(0.58)
E.B.S.	2.13	64.1	0.27	2.37	90.9	0.43
	(0.88)	(16.2)	(0.39)	(0.96)	(22.8)	(0.52)
F.C.D.	3.67	63.1	0.60	4.70	76.8	0.43
	(0.73)	(15.9)	(0.52)	(1.26)	(22.4)	(0.23)
M.Blf.	2.92	45.8	0.83	3.88	51.7	0.41
	(1.17)	(9.5)	(0.72)	(0.75)	(17.8)	(0.49)
Sw.	3.75	61.0	0.67	4.30	68.0	0.42
	(0.79)	(13.3)	(0.61)	(1.00)	(13.0)	(0.35)

NOTE.—R stands for number of syllables recalled; T, for time in seconds; Er., for errors. Figures in parentheses stand for mean variation. The times of day when each subject did the experiments and the number of records upon which the average is based are as follows: I.D.S., 7 P.M., 14 records; E.B.S., 7 P.M., 15 records; F.C.D., 8 A.M., 15 records; M.Blf., 1:30 P.M., 12 records; and Sw., 2:30 P.M., 12 records.

TABLE XXX

Sex	Work R.	Work Er.	Work T.	Rest R.	Rest Er.	Rest T.
Female	4.08	0.08	66.7	4.60	0.42	55.7
Female	2.92	1.08	122.0	3.17	1.83	130.4
Female	3.67	1.00	113.6	3.75	0.33	91.8
Female	3.42	0.25	68.7	3.92	0.42	80.2
Female	3.42	0.25	56.3	3.43	1.25	51.8
Female	1.75	2.92	106.2	3.92	1.92	98.0
Male	2.75	0.25	59.0	2.17	0.50	69.8
Male	5.33	0.00	54.2	5.33	0.30	86.0
Male	2.67	0.00	46.0	4.67	0.17	41.2
Male	4.82	0.70	67.0	5.50	0.30	69.0
Male	2.10	0.75	71.2	3.67	0.60	79.8
Male	2.83	0.33	57.2	3.25	0.25	52.3
Male	3.75	1.10	97.7	4.50	0.50	107.3
Male	4.00	0.50	72.0	5.60	0.10	62.3
Total	47.51	7.21	1048.8	57.48	8.89	1083.6
M.	3.39	0.52	74.9	4.10	0.64	77.4
M.V.	0.71			0.79		

Table gives averages for 14 untrained subjects (elementary psychology students). Non-sense syllables, Series A. Experiments done at various times of day from 10 A.M. until 5 P.M. Each average based upon six experiments, total experiments being 12.

A study of Table XXIX (trained subjects) shows in every case that more syllables are recalled after the REST interval. While the difference between the two methods is indeed slight, yet it is consistent and argues for retroaction. The error columns show nothing significant. As regards time of recall, every subject takes longer after the rest interval. The only plausible explanation we can offer for this is that after the work the syllables are gone so completely that, having reproduced a given number, the subject realizes the hopelessness of further attempt. Again, differences in attitude on the part of the subjects may possibly explain the situation.

Table XXX gives the averages for fourteen untrained subjects, based upon six experiments for each of the two kinds of intervals. The students were in the writer's elementary laboratory section, just beginning their laboratory work in psychology, and wholly ignorant of the purpose of the experiment.

The averages for these untrained subjects indicate quite clearly retroactive inhibition. Taking the individual cases, we find that twelve out of fourteen show such retroaction. In one case the method used does not seem to matter, while in one other case the subject does better after the work interval.

On the whole, the above experiments indicate clearly, we believe, a retroactive inhibition, a detrimental influence exerted by vigorous attentive work upon the original learning.

Experiment Series B. Using Method of Paired Associates Testing (1) *Rest versus Work Intervals.* (2) *Similarity of Work and Learning.*

In the following reported experimental section we have tried to get further data on (1) the comparison of rest and work intervals, and (2) by using relatively similar and dissimilar material in the work we have tried to find which type of work brings about the greater inhibition. In these experiments we have used two criteria for inhibition, namely, reaction times and the amount reproduced.

Apparatus and procedure: The exposure apparatus previously mentioned was used, with a reaction time addition. An Hipp, spring driven, chronoscope was used for measuring the reaction times. It was used on a simple make-break circuit, the " make " occurring as the test syllable was shown in the exposure window and the " break " occurring as the subject released the teeth key. The chronoscope was kept tested by means of a gravity chronoscope in which a steel ball, falling through one meter distance, operated the Hipp on a make-break arrangement. Our chronoscope has been fairly constant for our purposes, having a constant error of 28.3 sigma, ± 4.6 sigma.

Seven pairs of syllables were exposed to the subject fifteen times by means of the rotating drum and control lever. A pause of two seconds occurred after the eighth exposure. Each pair of syllables was exposed for one and a half seconds. A blank space was shown at the window between each syllable exposure. The subject pronounced with equal emphasis each pair of syllables as it appeared. Having given the fifteen exposures, any one of the following three procedures might be followed:

I. A rest period of five minutes. Test.
II. A work interval using relatively dissimilar learning material. Here the work consisted either in working simple

arithmetic or algebra problems or else in reasoning out the Thurstone reasoning problems. The work lasted for three minutes, then a rest of two minutes ensued. Test.

III. A work interval using relatively similar material. S. studied another set of seven syllables for one minute; worked for one and one-half minutes on the same material as given in II above; recalled syllables from the work series for one-half minute; rested two minutes. Test.

As will be seen, the total time between learning and testing is in all cases five minutes. In the test for recall the syllables constituting the left side of the pair (from the subject's side) were presented and in the following sequence: 5, 7, 1, 3, 6, 2, 4. (These numbers refer to the position of the syllables in the original learning.) The subject reacted by speaking aloud the associate syllable as soon as the syllable came to mind, or in case nothing came, the subject signified by saying "nothing." In either case the speaking broke the electrical contact and stopped the chronoscope.

The following tables give the results in terms of reaction times and number of associates reproduced, along with errors. We have treated the reaction times in three ways: (1) We have picked out from our records the wholly correct associates and thus compared the three methods; (2) we have combined the wholly right and half right associates; (3) all association times have been lumped together for each method used and thus compared. These thus include right, half right, errors, and reaction times giving "nothing."

If there is a positive retroaction it ought to be manifest in a comparison of Method I with either of the other two methods, II and III. We should expect the shortest reaction times for Method I, involving the rest interval. These results are found for only two subjects, F.C.D. and I.D.S., in the case of the right associates. For the other three subjects the data are conflicting—at least not clear. If we consider the times for correct and half correct associates, we find no evidence for retroaction in the case of any subject. Taking the association times for all reactions

TABLE XXXI

REACTION TIMES, FIVE TRAINED SUBJECTS

Subject	Times for Correct Associates			Times for Correct and Half Correct			Times for All Reactions		
	I	II	III	I	II	III	I	II	III
F.C.D.	3594	4664	4300	4782	4935	4320	6931	7398	5949
	(3126)	(3445)	(2839)	(4104)	(3423)	(2736)	(5929)	(5550)	(3919)
	N,31	N,35	N,31	N,37	N,39	N,34	N,56	N,62	N,54
I.D.S.	2443	2358	3540	2619	2419	3283	3686	3829	4605
	(1362)	(1244)	(1757)	(1555)	(1265)	(1766)	(2312)	(2155)	(2078)
	N,43	N,41	N,39	N,48	N,43	N,42	N,79	N,82	N,82
E.B.S.	3333	2790	2734	3688	2799	2997	4891	4696	4489
	(1856)	(1272)	(1271)	(1962)	(1195)	(....)	(2280)	(1918)	(1945)
	N,29	N,25	N,32	N,33	N,26	N,38	N,83	N,80	N,79
M.Blf.	3074	2866	3490	3314	2785	3460	4378	4062	5029
	(1225)	(1220)	(2100)	(1474)	(1163)	(1970)	(2342)	(2615)	(2510)
	N,23	N,28	N,19	N,31	N,30	N,25	N,56	N,54	N,55
Swk.	3888	4689	3669	3972	4526	3800	6530	7756	7188
	(2817)	(3117)	(1791)	(2697)	(2993)	(2283)	(4778)	(5686)	(4847)
	N,25	N,30	N,24	N,30	N,33	N,26	N,63	N,55	N,52
Group Mean	3266	3474	3547	3675	3493	3572	5283	5548	5452

In the table above the four place figures give the reaction times in sigma and are averages. The figures in parentheses are mean variations. N stands for the number of cases. Column headed I refers to Rest Interval; II, the Work Interval using Dissimilar work material; III, the Work Interval involving Similar work material.

TABLE XXXII

AMOUNT RECALLED AND ERRORS, FIVE TRAINED SUBJECTS

Subject	I. Rest		II. Work, Dissimilar		III. Work, Similar	
	R	Er.	R	Er.	R	Er.
E.B.S.	2.83	0.70	3.08	0.46	2.25	0.67
	(1.08)	(0.74)	(1.24)	(0.38)	(0.75)	(0.38)
I.D.S.	4.20	1.30	3.71	0.79	3.75	1.17
	(0.99)	(0.73)	(1.47)	(0.45)	(1.00)	(0.64)
Swk.	3.15	1.65	4.55	1.39	3.83	1.00
	(0.80)	(0.85)	(1.01)	(0.77)	(1.41)	(1.00)
M.Blf.	3.50	1.89	3.88	1.25	2.88	2.75
	(0.63)	(0.57)	(0.78)	(0.94)	(0.47)	(0.75)
F.C.D.	4.00	1.60	4.22	1.00	4.25	1.62
	(1.00)	(0.75)	(0.96)	(0.66)	(0.94)	(1.03)
Group Mean	3.54	1.43	3.89	0.98	3.39	1.44

Figures given in table are averages. Figures in parentheses give the mean variations.

under each method, we again find our results conflicting. Subjects Swk. and I.D.S. alone give data suggesting retroaction.

Table XXXII gives the amount of recall and errors under the headings R and Er., respectively. Comparing the results again as regards the rest as over against the two work intervals, we find that only one subject, I.D.S., indicates retroaction. Likewise the

group average signifies nothing. A study of the errors made also seems fruitless.

Our work (repeating in many ways the work of DeCamp) with the paired associates method has been largely barren of results. Strangely enough, we secure evidence of retroaction for single series of syllables, but our results are conflicting and often the very reverse of expectation when we used the paired associates material. Our only explanation is that fifteen exposures in this case fixes the associations too securely to permit retroaction. However, this hypothesis hardly seems justifiable as we review the struggles of the subject to recall the associate. A series of experiments must be carried on in which the number of exposures is greatly reduced in order to test this point.

The second problem investigated in this section has to do with the question of the degree of similarity of the work and learning material. A review of the two preceding tables gives the results for five trained subjects. The reaction times for Methods I and II (Table XXXI) show only two cases, when right associates are taken, where the similar work material exerts a greater retroaction than the dissimilar. For the other four subjects the reverse is true. The other studies of the times in the table are likewise conflicting. If the more similar work material exerts greater retroaction than the dissimilar, then we might expect a longer reaction time in the former case. Our results do not indicate that such is the case under the conditions of our experiment. If we turn to the errors and amount recalled (Table XXXII) we find some evidence that the more similar work exerts greater retroaction than the less similar. In three cases R is less for the similar work than for the dissimilar, and in the two cases where the reverse is found the difference is very small. Taking the group averages, there is a slight advantage in the case of the dissimilar work. If we overlook the fact that our reaction times failed to reveal anything, our evidence indicates that the more similar the work and learning, the greater is the retroactive effect.

Experiment Series C. Single Syllables
Similar versus Dissimilar Work

In the following section we have used eight untrained subjects and single series of nonsense syllables. The series of seven syllables was exposed on the rotating drum at the rate of one per 1.2 seconds. Three exposures were given, the subject saying aloud each syllable as it came to view. After the exposure S. either worked for three minutes on Thurstone reasoning problems or else worked for two and one-half minutes studying fourteen new syllables, taking the last half minute to recall these syllables. Six experiments were done at one sitting. Each subject did his experiments at the same time of day, although different subjects did their work at different times.

There were four men and four women, all elementary psychology students having had some laboratory work but no previous work with nonsense syllables. They merely knew the general nature of the experiment, namely, that it had to do with inhibition. In the recall the first syllable was always given to the subject. A perfect recall would thus be six syllables. The time taken in recall was measured by a stop watch. The following table, XXXIII, gives the individual and group averages:

TABLE XXXIII

	Similar			Dissimilar		
	R	Er.	T	R	Er.	T
	0.83	1.70	104.8	1.88	1.50	151.0
	1.75	0.25	45.2	2.92	0.25	48.3
	0.90	0.50	88.2	2.60	0.50	116.4
	1.92	0.75	92.5	2.00	0.67	92.3
	1.00	0.83	46.5	1.33	0.33	75.0
	1.67	1.00	13.5	2.25	1.08	116.7
	2.33	0.50	128.7	3.83	0.50	141.3
	2.08	5.83	103.0	2.33	1.17	140.7
Total	12.48	11.36	622.4	19.14	6.00	881.7
Mean	1.56	1.42	77.8	2.36	0.75	110.2
M.V.	0.48			0.54		

Without exception, every subject recalled more syllables when the work was dissimilar. Likewise the errors made are greater in the case of the similar work. The similar work apparently involves a greater retroaction.

Experiment Series D. Effect of Varying Temporal Position of Interpolated Work, Single Syllables

In the following report series of seven nonsense syllables were used as the original learning material. The method of exposing and learning was similar to that in Experiment Series C. The interpolated work consisted in working algebra and arithmetic problems, and, as such, was a constant condition. The condition which we have tried to vary is the length of time elapsing between original learning and work interpolation. The total time was the same for each experiment, namely, six minutes. Three variant intervals or combinations were used, as follows (figures indicating minutes):

I. L—W3—R3—Test.
II. L—R1—W3—R2—Test.
III. L—R3—W3—Test.

On any experiment day six experiments were done; that is, each of the above three was done twice. An interval of from two to three minutes intervened between each experiment. In the test E. gave S. in every case the first syllable. Thus there remained six syllables to be reproduced. Half credit was given for those syllables in which two consecutive letters were correct.

In the following table, XXXIV, are given the results from five trained subjects. The column headed R gives the average amount reproduced (six being a perfect score); Er. stands for the average error; and T signifies the time taken in recall. Unfortunately, the experiments had to be done at different times of day. E.B.S. and I.D.S. did their experiments at 7 P.M.; F.C.D., at 8 A.M.; Swk., at 2:30 P.M.; and Blf., at 10 A.M.

Taking first the group average, it will be noted that, while the difference is not great, there is a better recall when a rest interval of three minutes intervenes than when the work is introduced immediately. The intermediate combination II, however, gives the best results. The averages for this intermediate method are based upon relatively few records (unfortunately) in the case of three subjects.

Studying the data by subjects, we note that I.D.S. and E.B.S.

give rather clear results, a decreasing value of R as we read across the table from left to right. F.C.D. and Swk., while doing better (apparently) by the Method II, yet indicate in their averages that there is more retroaction when the work is introduced immediately than when a rest of three minutes intervenes. Blf. alone fails to indicate a greater retroaction when the work is introduced immediately. On the whole the data of Table XXXIV indicate that work introduced immediately after learning gives the greatest retroaction.

As a check series some further experiments were done with thirteen untrained subjects. These experiments were similar to the above excepting that the total time was seven minutes rather

TABLE XXXIV

	L–R3–W3			L–R1–W3–R2			L–W3–R3		
Subject	R	Er.	T	R	Er.	T	R	Er.	T
E.B.S.	2.04	0.80	97.3	1.45	0.45	82.5	1.30	0.62	70.4
	(0.97)	(0.63)	(16.8)	(1.04)	(0.58)	(20.5)	(0.10)	(0.50)	(25.4)
	N,12	N,12	N,12	N,11	N,11	N,10	N,12	N,12	N,12
I.D.S.	3.75	0.33	68.0	3.10	0.40	65.4	2.63	0.88	64.0
	(1.04)	(0.44)	(20.0)	(1.22)	(0.40)	(17.7)	(1.15)	(0.86)	(20.7)
	N,12	N,12	N,12	N,10	N,10	N,10	N,12	N,12	N,12
F.C.D.	3.30	0.60	72.0	5.20	0.20	59.0	2.95	0.55	71.0
	(1.24)	(0.46)	(25.0)	(0.32)	(0.32)	(22.0)	(1.17)	(0.54)	(19.0)
	N,10	N,10	N,9	N,5	N,5	N,5	N,10	N,10	N,10
Swk.	3.05	0.45	77.1	4.67	0.00	64.5	2.85	1.05	100.3
	(0.67)	(0.36)	(22.9)	(0.89)	(0.00)	(19.5)	(1.05)	(0.47)	(22.9)
	N,10	N,10	N,10	N,6	N,6	N,6	N,10	N,10	N,10
Blf.	3.95	0.70	54.6	4.30	0.86	41.7	4.20	0.40	51.5
	(1.04)	(0.68)	(10.6)	(0.33)	(0.49)	(6.6)	(1.04)	(0.32)	(6.8)
	N,10	N,10	N,10	N,7	N,7	N,7	N,10	N,10	N,10
Group Aver.	3.22	0.58	73.8	3.75	0.38	62.6	2.79	0.70	71.4

Figures in parentheses give M.V. N signifies number of experiments.

than six. In all cases S. spent the last minute just before recall in glancing through a magazine. Only two combinations were used, the I and III above.

Table XXXV gives the results. The averages are based upon only four experiments for each combination. The work consisted, on the first experiment day, in working out Thurstone reasoning problems and, on the second day, doing simple algebra and arithmetic problems.

The above table indicates nothing definite. The group averages indicate a slightly greater recall when a rest period inter-

TABLE XXXV

Sex	R2 W3 M1 R	Er.	T	W3 R2 M1 R	Er.	T
Male	3.5	0.75	91.2	3.3	0.75	58.2
Male	2.8	0.50	70.2	2.5	1.00	68.5
Male	1.6	0.88	75.5	0.8	2.00	81.0
Male	2.5	1.50	78.2	3.5	1.12	108.0
Female	2.9	1.38	98.2	3.6	1.12	75.0
Male	3.3	0.50	40.9	2.5	0.50	40.7
Male	3.2	0.62	41.5	3.4	0.38	38.2
Female	4.1	0.88	104.7	3.0	0.38	97.5
Male	2.6	0.12	51.7	3.3	0.25	33.5
Male	2.3	0.25	48.2	2.5	0.25	49.0
Female	3.1	1.10	74.8	2.0	0.50	101.2
Female	4.2	0.88	45.0	3.7	1.00	56.7
Male	2.3	0.75	47.0	1.3	1.25	51.2
Total	38.4	11.11	875.2	35.4	10.50	858.7
M.	2.95	0.85	67.3	2.72	0.80	57.3
M.V.	0.57	0.31	18.6	0.73	0.41	20.2

venes before the work, as compared to the condition where the work comes immediately. Seven individuals show greater retroaction when the work comes immediately, while six give opposite results.

Basing our statement on the work of the trained subjects, we may say that there is a positive indication that the temporal position of the work is important.

Experiment Series E. Effect of Varying Temporal Position of Work, Paired Associates Method

The problem investigated in this series is the same as that considered in the Series D preceding. However, we have here tried to test the matter of the importance of the temporal position by using the paired-associates method. The arrangement of the pairs, their presentation, and method of testing was the same as mentioned in Series B preceding. Two different methods were used and compared, as follows:

I. L (15 exposures)—W3—R3—Catalogue 1—Test.
II. L (15 exposures)—R3—W3—Catalogue 1—Test.

In each of the above methods the subject spent the last minute glancing at the pages of an apparatus catalogue. The records of five trained subjects appear in the following tables, XXXVI and

XXXVII. Three experiments were done at each sitting, two of one method and one of the other. On the day following, this was reversed. The subjects did their experiments at the same times as mentioned in Series B. The presentation of the methods was irregular and S. did not know what to expect next. Table XXXVI gives the means, the mean variations (figures in parentheses), and the number of experiments upon which the means are based. These means represent the average number of syllables (associates) reproduced correctly (column headed R), and the errors (column headed Er.). Table XXXVII gives the reaction times in sigma, the mean variations, and the number of cases.

TABLE XXXVI

Subject	R3 W3 C1 R	R3 W3 C1 Er.	W3 R3 C1 R	W3 R3 C1 Er.
Swk.	4.07	1.57	4.36	1.07
	(1.35)	(0.80)	(0.77)	(0.80)
	N,7	N,7	N,7	N,7
M.Blf.	3.61	1.94	2.55	2.67
	(1.37)	(1.16)	(1.42)	(0.99)
	N,9	N,9	N,9	N,9
F.C.D.	5.00	1.00	4.11	1.00
	(1.22)	(0.55)	(1.12)	(0.67)
	N,9	N,9	N,9	N,9
E.B.S.	2.81	0.89	2.51	0.96
	(0.98)	(0.46)	(1.30)	(0.88)
	N,13	N,13	N,13	N,13
I.D.S.	4.40	1.50	4.80	1.00
	(1.30)	(0.83)	(0.73)	(0.33)
	N,11	N,11	N,12	N,12
Group Mean	3.98	1.38	3.67	1.37

Studying Table XXXVI, we note that the group average indicates an advantage with regard to amount reproduced for the method in which a rest interval of three minutes intervenes between the original learning and work. The errors are the same. Three subjects give more associates when the work is delayed, whereas in two cases (I.D.S. and Swk.) there is a slight advantage for the method which involves the immediate introduction of the work.

Turning now to the reaction times (Table XXXVII) and inspecting first the group average, we note, for the correct associates, that the mean reaction time is 125 sigma longer when the

work is introduced immediately. Considering columns three and four in the table, which give the times for both correct and half correct associates reproduced, we find the same thing, excepting that here the difference is greater, namely, 369 sigma. It will be noted that in the case of Swk. we have used a smaller set of means than that listed above his mean variations. We have taken out three very extreme times from his records and this gave us the smaller averages. These extreme records were thrown out as

TABLE XXXVII

Subject	Reaction Times for Wholly Correct Associates		Reaction Times for Correct and Half Correct Associates	
	R3 W3 C1	W3 R3 C1	R3 W3 C1	W3 R3 C1
Swk.	6026	3965	5564	5375
	(4921)	(2557)	(4268)	(3516)
	N,24	N,27	N,30	N,34
	*3967	3472	3702	3418
Blf.	2701	2465	2699	2903
	(1401)	(1248)	(1327)	(1739)
	N,30	N,20	N,33	N,26
F.C.D.	4149	4580	4111	5236
	(2898)	(3081)	(2768)	(3709)
	N,43	N,35	N,45	N,37
E.B.S.	2775	2368	2941	2333
	(1496)	(1408)	(1583)	(1381)
	N,34	N,32	N,37	N,33
I.D.S.	2327	3660	2447	3854
	(1253)	(2334)	(1370)	(2502)
	N,43	N,54	N,48	N,62
Group Mean	3184	3309	3180	3549

* This row of means used in all calculations.

the subject reported that he had the associate but held on to it overtime. Consequently we have used his smaller average, in which these three very extreme reaction times are omitted from consideration.

Subject Swk. gives a reaction time longer for Method II, although this difference stands out greater than the difference between the two methods as regards amount reproduced. About the same can be said for E.B.S., his reaction times being shorter when he works immediately after the learning. F.Blf. gives a shorter reaction time for Method I (immediate work) in case of correct associates. However, when we consider together the correct and half correct associates given the reverse is true. We

are inclined to stress columns III and IV in our table above for it is these half correct associates which represent the hesitations and blockings noted in the subject's reactions. Considered from the standpoint of either correct or correct and half correct associates, the results from F.C.D. show a longer reaction time when the work follows immediately. While, as we saw above, I.D.S. reproduces as many associates for Method I as for Method II, a study of the reaction times gives a clear case for Method II. The reaction times are longer when the work is introduced immediately.

We believe that a careful analysis of the above results justifies us in saying that the temporal position is important—that work introduced immediately causes more retroaction (as judged by a longer reaction time and a smaller number of recalled associates) than the method wherein the work is not introduced until after three minutes. We have some individual (apparent) exceptions. Some other form of work activity, a longer period of work activity, less number of exposures in the original learning—these and other differing conditions might have yielded us, even for these apparent exceptions, results confirmatory of our above generalization. Certainly we must say that there seem to be individual differences indicated as regards susceptibility to retroaction in the above experiments. The work in Series D, using single syllables, likewise lends weight to our generalizations as stated above.

PART V. EXPERIMENTAL SECTION

GENERAL SUMMARY OF THE INVESTIGATION

There remains the task of bringing together the results of the various experimental series.

I. The experiments involving the reconstruction test for original learning indicate very clearly that it is better to rest after the learning than to turn immediately to some other vigorous and taxing work. That is to say, learning after a rest interval can be recalled better than after a work interval.

The same results have been found in the case of series of sense words as original learning. Likewise the use of single series of nonsense syllables showed the same results. However, when we used series of paired associates and tested by the method of right associates and reaction times, our results were conflicting.

II. Our data indicate that the degree of similarity between the original learning and the interpolated work activity is important. Within limits, the more similar the original learning and the interpolated work the more detrimental will be the effect upon the efficiency of recall of the original material. The matter of " within limits " must be stressed here. The data from the reconstruction test is quite definite in justifying the above statements. In the case of single series of nonsense syllables it was also found that the more similar the work and learning material the greater the detrimental influence on recall of the original learning. Again, the reaction times of the paired-associates (nonsense syllables) experiments failed to give clear results, although the amount reproduced indicates a greater retroaction when the work and learning are similar.

Our work substantiates Robinson's results in the matter of the importance of the degree of similarity of work and original learning. We must hasten to add certain limitations and additions to the general statements preceding:

A. When work and original learning are identical in content and method there is only reinforcement or repetition. There is no inhibition.

B. As the material is made (by degrees) more and more dissimilar the reinforcing factors gradually diminish in effectiveness and the interfering factors become more and more pronounced.

C. As the material of learning and work is made more dissimilar a point is reached where there is a maximum of interference or detrimental influence wrought upon the original learning.

D. Beyond this point the curve of interference or detrimental influence goes downward, and then we can say that the more dissimilar the materials the LESS the detrimental influence.

E. However, the curve of detrimental influence never reaches zero because after the work and learning are as different as can possibly be made there is still a damaging influence exerted by the work.

We have found it very difficult to make out a graded series of work activities differing in degree of similarity from the original learning.

III. All the data which we have accumulated indicate that the temporal position of the interpolated work is important. Work introduced immediately following the original learning is more detrimental in its influence on that original learning than work introduced after a rest interval. Reconstruction test data, single series of nonsense syllables, and paired series of nonsense syllables indicate the above conclusion. The little work done with sense words alone is conflicting.

These results confirm the results found by Müller and Pilzecker and are opposed to the findings of Robinson, who rejects the matter of temporal position of the interpolated work as unimportant.

IV. On the basis of the data from the reconstruction experiments there seems evidence that as the subject becomes more and

more fatigued in the course of the day's series the work activity acts relatively more detrimentally upon the original learning.

Tolman found that there is a more detrimental influence of work upon learning in the evening than in the morning. Our investigation of the relative effects of work activity in the morning and evening, however, fail to confirm Tolman's conclusions. When learning was as good in the evening as in the morning there was no evidence that the work interpolated was more detrimental.

V. As regards the effects of practice, our data are not as positive as we would wish. As the subject becomes more and more practiced with the original learning material will there be less and less detrimental influence exerted by the work activity? Robinson has suggested this. In the case of the sense words our results actually indicate that as the subject becomes more practiced there is an increase in the detrimental action of the work material. The results from the reconstruction test are conflicting.

Our data show that as the subjects become more practiced with the original learning material the learning itself is better, the subject learns more easily, and can retain longer. Certain efficient methods of learning become selected by the trial and error process as one becomes practiced with a given learning material.

VI. Certain general statements may be made here concerning the rest and work periods. Two years of working on this investigation have emphasized to us the following points:

A. Trained subjects are a necessity. One cannot know about the nature of the " rest " interval unless the subject gives a detailed and careful report of what went on " within." Only the subject can tell whether the work activity was " difficult or easy," " interesting or boresome," " attentive or inattentive," etc.

B. The number of " rest " intervals which are near ideal from the standpoint of " mental passivity " and absence of all thought of the original learning is relatively few. Most rest intervals are characterized by either some " return " to consciousness of the original learning or else the subject becomes active mentally upon some line of thought.

C. As subjects become practiced they are better able to take an indifferent and passive attitude during the rest interval.

D. In most cases where there was reported some consciousness of the original learning during the rest interval it was very vague and fragmentary, often taking the form of merely desiring to recall it with a feeling that it was near at hand.

E. It is important that work which will combine interest and maximum effort be secured for the work activity. We have found reasoning problems of a logical and mathematical nature the most satisfactory work material.

BIBLIOGRAPHY

I. Major Experimental Investigations of Retroactive Inhibition

1. DeCamp, J. E. A Study of Retroactive Inhibition. Psychological Monograph, XIX, 1915.
2. Heine, Rosa. Uber Wiedererkennen und rückwirkende Hemmung. *Zeitschrift fur Psychologie,* 68, 1914, 161–236.
3. Müller, G. E., and Pilzecker, A. Experimental Beiträge zur Lehre vom Gedächtniss. *Zeitsch. fur Psych.,* Erganzungsband I, 1900, 174–198.
4. Robinson, E. S. Some Factors Determining the Degree of Retroactive Inhibition. Psych. Monograph, XXVII, 1920.
5. Tolman, E. C. Retroactive Inhibition as Affected by Conditions of Learning. Psych. Monograph, XXV, 1917–1918.
6. Webb, L. W. Transfer of Training and Retroaction. Psych. Monograph, XXIV, 1917.

II. Other Experimental Studies and Discussions Bearing Upon the Problems of Retroactive Inhibition, and Inhibition in General

7. Angell and Moore. Study in Attention and Habit. *Psych. Rev.,* III, 1896, 245–258.
8. Bair, J. H. The Practice Curve. Psych. Monograph, V, 1902.
9. Breese, B. B. On Inhibition. Psych. Monograph, III. Also, Text Book, Psychology., 1917, p. 282ff.
10. Brockbank, T. W. Redintegration in the Albino Rat. Behavior Monograph, IV, 1919.
11. Dashiell, J. F. Comparison of Complete vs. Alternate Methods of Learning Two Habits. *Psy. Rev.,* 27, 1920, 112–135.
12. Griffitts, C. H. Results of Some Experiments on Affection, Distribution of Associations, and Recall. *Jr. Expt. Psych.,* III, 1920, 447–464.
13. Herrick, C. J. Introduction to Neurology. 1916. W. B. Saunders.
14. Holmes, S. J. Studies in Animal Behavior.
15. Howell, W. H. Textbook of Physiology. Seventh Edition. W. B. Saunders.
16. Hunter, W. General Psychology, p. 304. Habit Interference in the White Rat and Human Subjects. *Jr. Compar. Psych.,* II, 1922, 29–61.
17. Jesinghaus, C. Wundt's Psychologische Studien, 7, 1911, p. 363.

18. Pechstein, L. A. Whole vs. Part Methods in Motor Learning. A Comparative Study. Psych. Monograph, XXIII, 1917.
19. Pillsbury, W. B. Fundamentals of Psychology, pp. 89f, 358f, 364f. Essentials of Psychology, pp. 213f, 221f, 215f.
20. Pyle, W. H. Transfer and Interference in Card Distribution. *Jr. Ed. Psych.,* 10, 1919, 107–110.
21. Shepard, J. F., and Folsenberger, H. M. Studies in Association and Inhibition. *Psy. Rev.,* XX, 1913.
22. Sherrington, C. S. Integrative Action of the Nervous System. Yale Univ. Press, 1906.
23. Smith, W. W. Experiments on Memory and Affective Tone. *British Jr. Psych.,* 11, 1920–21, 236–250.
24. Yerkes, R. M. Inhibition and Reinforcement of Reactions in the Frog. *Jr. of Compar. Neur. and Psych.,* XIV, 124.

III. Pathological Cases of Inhibition

25. Bastian, H. C. Amnesia and Other Speech Defects. *Med. Chir. Trans.,* LXXX, 61–86.
26. Briggs, W. Verbal Amnesia Due to Shock. *St. Louis Med. and Surg. Jr.,* 1887, LIII, 279–281.
27. Cowles, E. Epilepsy with Retrograde Amnesia. *Am. Jr. Insanity,* 1900, 593–614.
28. Dana, C. L. The Study of a Case of Amnesia or Double Consciousness. *Psy. Rev.,* I, 1894, 570–580.
29. Hopkins, S. D. Amnesia, with Report of a Case. Trans. Col. State Med. Soc., 1902, 365–367.
30. Kraffe-Ebing, R. Ueber retrograde allgemeine Amnesia. Arbeit a. d. gesamm. Geb. d. Psychiat. und Neuropath., Leipzig, 1898.
31. Naef. Ein Fall in temporarei, totaler, theilweise Amnesia. *Zeitsch. f. Hypnotismus,* VI, 1897, 321–355.
32. Paul, M. Beiträge zur Frage der retrograden Amnesie. *Arch. f. Psychiat.,* Berlin, 1899, XXXII, 251–282.
33. Sidis, Boris. Psychopathological Researches. Studies in Mental Dissociation. New York, 1902.
34. Stratton, G. M. Retroactive Hyperamnesia and Other Emotional Effects on Memory. *Psy. Rev.,* 1918, 26, 474–486. (The nine preceding references given in Stratton's bibliography.)